(PUBLISHED QUARTERLY)

Journal of the Council for Scientific and Industrial Research.

Vol. 6. AUGUST, 1933. No. 3.

Botulism of Sheep in Western Australia and its Association with Sarcophagia.

*By H. W. Bennetts, D.V.Sc.**

The report that follows deals with work forming part of a programme of investigations which the Council and the Western Australian Department of Agriculture have been carrying out in co-operation. Dr. Bennetts has been seconded to the Council from the Department, and the latter provides laboratory accommodation, an experimental field station, travelling facilities, &c.—ED.

Summary.

1. Botulism of sheep was first recorded in Western Australia in 1928. Since then, the annual incidence has progressively increased. This disease is now regarded as being a source of greater economic loss than all other diseases affecting sheep in Western Australia. It is due to the ingestion of toxic rabbit carrion.

2. The high incidence in Western Australia, as compared with that recorded in other parts of Australia, is ascribed to the annual long dry period extending over many months. The great increase in the rabbit population, combined with the attempted destruction by poisoning, results in abundant carrion being available during this period when depravity of appetite is acute.

3. It is suggested that the term "sarcophagia" is appropriate for the condition described, and that further work should be undertaken to determine the actual cause and means of prevention of this condition.

4. The clinical features of the disease are described.

5. *B. parabotulinus* has been isolated from rabbit carrion.

I. Introduction.

Botulism in cattle has been of frequent occurrence in Western Australia for a number of years. An accurate description of the syndrome was recorded departmentally as early as 1896. The nature of the disease was not definitely determined until 1922, when Seddon confirmed Filmer's clinical diagnosis by isolating *B. parabotulinus* from bones forwarded from a property in the Great Southern district.

* Senior Veterinary Research Officer, C.S.I.R., seconded from the Western Australian Department of Agriculture.

Horses, not uncommonly, are affected with a condition which on clinical grounds alone appears to be botulism.

Botulism in sheep has been deemed the cause of a very heavy annual mortality, and indeed to be the source of greater economic loss than all other diseases. This is quite contrary to the general Australian experience. It has been recorded in only one other State—that of New South Wales—where it does not seem to be common. Seddon (4) refers to one outbreak in 1925 which resulted from ingestion of rabbit carcasses, and later (5) stated that bone-chewing "may on occasion be exhibited by sheep"; Rose and Edgar (3) recorded a similar mortality in 1929 where 20 sheep died out of a flock of 400. In the last instance, *B. botulinus* type B was isolated from the rabbit carrion. Seddon and Carne (6) had obtained it previously from a similar source.

The organism responsible in Western Australia would appear to be *B. parabotulinus*, which is now recorded here as having been isolated from rabbit carrion. In 1928, toxicogenic saprophytes were isolated from the femur of a sheep, which had died from this disease, and from rabbit carrion, but they were never typed out.

The remarkable incidence in this State is evidently due to conditions which are peculiar to it, and a more detailed account than that given in the first record (Bennetts (1)) will not be without interest.

2. Nature of the Disease.

(i) *History.*—The disease was first recognized in January, 1928, when the owner of a property in the Merredin district reported that his sheep were dying from what he considered to be braxy-like disease. The writer investigated and diagnosed the condition as botulism, as the result of the examination of three animals. In a flock of approximately 400 depastured on wheat stubble, a number of sheep were observed to be eagerly eating rabbit carrion dug out of a warren that had been fumigated with carbon bisulphide several months previously. Fifteen sheep died. The diagnosis was confirmed by the isolation of a toxicogenic saprophyte from the femur of a sheep dead for some weeks. Towards the latter part of the same summer, similar outbreaks, following ingestion of poisoned (phosphorus) rabbits' flesh were investigated in other centres of the wheat belt.

It has been established that the disease appeared sporadically during 1927, but no evidence has been obtainable that serious losses were experienced prior to 1928. Since then, judging by reports, it has become progressively more widespread, and the serious mortalities occurring annually throughout the wheat belt are causing considerable concern at the present time.

(ii) *Distribution and Economic Importance.*—The disease is now known to occur practically throughout the whole of the sheep-carrying portion of the South-western Division of the State. It occurs generally as widely-separated outbreaks except in the Eastern Wheat Belt, where, over a large area of country, very heavy losses are experienced annually. The death rate is said to be as high as 50 per cent. in some flocks.

(iii) *Incidence.*—From information available, the annual incidence is steadily increasing. There is a very definite seasonal incidence from January to May. With the advent of green feed following the winter rains, the disease disappears. There is no evidence that sex, breed, or age affect the incidence. Our own observations indicate, however, that it is usually the best-grown and best-conditioned sheep in the flock which become affected.

(iv) *Clinical Description.*—Usually, the period between the onset of symptoms and death is one to two days. Affected animals occasionally linger for several days and, rarely, recovery takes place. The syndrome is typically botulinic. The initial sign is a spasmodic wriggling of the tail as though fly-blown. Later, the animal shows a stiff gait and a disinclination to move, and becomes separated from the flock. It progresses for only short distances, and then lies down in a position of sternal decubitus. Appetite is lost and rumination suppressed. The head is held in a drooped position, and there is frequently a more or less profuse flow of saliva, with sometimes protrusion of the tongue. Constipation is usual. Paralysis of the hind limbs becomes marked, and finally the animal is unable to rise. Respiration becomes spasmodic and abdominal, the intercostal muscles not functioning. Death takes place quietly in the position of normal decubitus.

(v) *Post-mortem Appearances.*—There are no gross pathological changes. The gall bladder is distended with bile, and the large bowel is frequently packed with hard, dry ingesta. Remnants of rabbit carcasses, though often difficult to recognize, may be found in the rumen and reticulum.

(vi) *Etiological Factors.*—The condition appears to be invariably associated with ingestion of rabbit carrion. The main factors responsible for the serious incidence of the disease are believed to be two—the unusually long dry period, which is of normal occurrence, resulting in a reduced phosphorus content of pastures and other dietetic deficiencies (including protein), and the rabbit pest, which, through measures taken to cope with it, means numerous decaying carcasses.

Seasonal and Dietetic.—The seasonal conditions differ from those found in other parts of Australia. In the South-western Division, there are, broadly speaking, two seasons—a period of reliable and adequate rainfall with green pasture, extending over four to five months from May or June until September, and alternating with a period of seven to eight months, when little or no rain falls and the herbage is dry; then, unless supplements, mineral and other, are fed, sheep tend to exhibit a depraved appetite. This is manifested in a relish for rabbit droppings* and rabbit carrion in all stages of decomposition. On occasions, sheep have been seen, when driven around the paddock, to continue chewing carcasses which they had picked up before being disturbed. On one property, green lucerne, rabbit carcasses, and mounds of rabbit droppings were all exposed to a mob of sheep in which mortality had been occurring: they showed a decided preference for the droppings, which they ate quite eagerly—the lucerne proving relatively unattractive.

* It appears distinctly unlikely that rabbit faeces would provide a suitable medium for the growth and toxin production of *B. parabotulinus* so that ingestion would tend to botulism. However, the possibility should be considered pending experimental evidence.

As a result of Theiler's well-known work on lamsiekte in South Africa, as well as Australian observations, it is generally accepted that osteophagia results from phosphorus deficiency in the diet. Western Australia, except for a few small areas, is markedly phosphorus deficient. The following table (7) shows P_2O_5 content of soil in two widely-separated areas where the disease occurs.

Table 1.

District.	Soil.	
	Total P_2O_5. Per cent.	Available P_2O_5. Per cent.
Merredin—		
Location 1 (0″–9″)	0·022	0·009
(9″–18″)	0·024	..
Location 2 (0″–9″)	0·022	0·005
(9″–18″)	0·015	..
Chapman—		
Location 1 (0″–9″)	0·036	0·009
(9″–18″)	0·048	..
Location 2 (0″–9″)	0·019	0·006
(9″–18″)	0·030	..

The figures for available phosphorus appear to be rather high. Teakle (8) found an almost complete absence of water soluble phosphate from Merredin and other wheat belt soils. Unfortunately, we have no available figures for dry "pasture" in the affected area. The P_2O_5 content of a sample of dry pasture from a property where sheep eat rabbit droppings, but on which botulism is not known to occur, was 0.147 per cent. Analyses of pasture from other areas in the State indicate, as elsewhere, that even where the phosphorus content is relatively high in the green feed, it falls very considerably in the corresponding dry feed. It appears evident that the effect of low phosphorus content of soil is secondary to the dominant influence of the long dry period.

Throughout the Eastern Wheat Belt, the general practice is to run sheep on wheat stubbles or fallow paddocks during the dry period, and towards the end of the summer little feed is left other than dry innutritious grasses and wheat straw. Two samples of wheat stubble from Merredin analysed by Dr. Underwood* were found to contain 0.06 and 0.07 per cent. P_2O_5, and were probably deficient in most other requirements. In these districts generally, no provision is made for supplementary feeding of sheep during this period. In the Great Southern District, however, which is primarily a sheep-raising area, oats are grown extensively, and supplementary feeding with chaff, oats, linseed "nuts," &c., is resorted to. In these circumstances, depraved appetites are not noted, and botulism is rarely encountered in sheep, although in cattle, osteophagia and botulism are by no means uncommon throughout. Rabbits are not so numerous there, and the comparative paucity of rabbit carrion may be a factor, but it is not of major importance.

* Animal Nutrition Officer of the Western Australian Department of Agriculture.

Carrion eating by sheep, which may be termed "sarcophagia"—it can hardly be described as osteophagia—is usually ascribed to phosphate deficiency, and preventive measures recommended accordingly. They have not been an unqualified success in Western Australia, and it is becoming evident that phosphorus deficiency is not alone responsible for the depraved appetite exhibited. It is rather remarkable that Wheat Belt sheep are notable locally for being large framed. Their growth is naturally much more rapid during the period when green feed is available, but the growth limiting effect of acute phosphorus deficiency reported in South Africa is not noted, nor have any gross bone changes been observed.

Rabbits.—The rabbit population has multiplied enormously during the last six to seven years, particularly throughout the Wheat Belt areas. Rabbit poisoning is compulsory. During the early dry months of the year, phosphorus baits are extensively laid, and dams are often fenced off and cyanided water provided for the rabbits. As a result, during the late summer and autumn months when the depraved appetites of the sheep have become acute, large numbers of rabbit carcasses are distributed over the countryside. Even if cleaning up of carcasses is attempted, it is difficult to remove them all from the stubbles, and sometimes losses have been experienced as a result of rabbits dying on properties other than those on which they had been poisoned, the owners being at the time ignorant of their existence.

Rose and Edgar, in New South Wales, have adduced some evidence indicating that the infection of carrion with *B. botulinus* probably took place from the intestinal tract of the rabbits and not from the adjacent soil. Field evidence here also suggests that rabbits carry the organism responsible (in this case apparently *B. parabotulinus*) as a normal bowel inhabitant, and thus assist in distributing the organism. It is otherwise hard to explain the rapid spread of the disease, particularly to country which is lightly stocked and much of which has only been cultivated or stocked for upwards of five years. Rabbits, when abundant, also probably contribute towards a greater incidence of the disease by eating out much of the best feed.

The low price of wheat for the past few years has resulted in a decreased use of superphosphates, and the financial depression has led to an increase in rabbit population owing to a relaxation in the offensive against them. These factors may have contributed towards the greatly increased incidence of the disease during the past three or four years.

3. Prevention.

Following the diagnosis of the disease in 1928, the feeding of phosphates was advocated as a preventive of the depraved appetite which resulted in carrion eating. A lick composed of bone meal and salt in equal parts was recommended and the results obtained were reported to be satisfactory. It was considered, however, that this procedure was uneconomic owing to the high cost of bone meal, and the Department of Agriculture has recommended licks containing mineral phosphate. Since 1932, a lick composed of di-calcic phosphate, molasses, and salt (18 per cent. P_2O_5) has been in general use. These mineral licks have not always proved palatable, and frequently it has been necessary to add crushed oats, or to increase the percentage of salt or of molasses, until

sheep become accustomed to them. Undiluted lick is then taken quite readily. Sheep on one property consumed 4 oz. per head per week during the latter part of the dry period. In this case, botulism, which had been enzootic prior to the use of licks, disappeared, but the results obtained generally in the prevention of carrion eating have not been entirely satisfactory.

In some instances, failure has evidently been due to the following factors:—

(*a*) Consumption of inadequate quantities of lick.

(*b*) Too great delay in the provision of lick. When once the depraved appetite is developed, sheep definitely prefer carrion to licks containing mineral phosphates, or even bone meal.

(*c*) The use of unsuitable licks. Despite extensive propaganda, proprietary and other licks containing totally inadequate amounts of phosphate have been used alone, or in conjunction with those advised.

Phosphorus deficiency alone may not be entirely responsible for the depraved appetite which manifests itself in carrion eating. There is sufficient evidence to warrant a more systematic and exhaustive collection of field data than are at present available. This should be accompanied by appropriate chemical investigation and experimental work. A protein deficiency suggests itself as being possibly contributory to the depraved appetite exhibited by sheep on dry pasture, and Filmer (2) has recommended oats as a summer feed for sheep, as they supply both phosphorus and some protein. He also points out that they may be used with the prescribed licks in order to solve the question of palatability in a convenient and economical manner. That this would greatly minimize the losses from botulism is indicated by the comparative immunity of the Great Southern District where the provision of oats alone appears to prevent the occurrence of depraved appetite.

It has been suggested that preventive inoculation with anaculture would be a more economical way of dealing with the difficulty under present conditions, and experimental work is projected.

The collection and proper disposal of all rabbit carrion is of course recommended, but the difficulties are obvious.

4. The Isolation of *B. parabotulinus* from Rabbit Carrion.

As already stated, toxicogenic saprophytes originally isolated from rabbit carrion and a sheep bone were not typed.

Further material was examined this year with the object of determining the organism responsible for the botulinic syndrome in sheep, and, after two unsuccessful attempts, a toxicogenic saprophyte has been isolated, and by means of toxin-antitoxin tests determined to be *B. parabotulinus*. In May last, rabbit carcasses were received from a property in the Northam district, where 120 sheep had died out of a flock of 1,100 being grazed on wheat stubble. The cause of death was diagnosed as botulism.

Method of Isolation.—The rabbit carrion was in various stages of decomposition. Some was moist and contained maggots, but the majority was quite dry, and practically skin, fur, and bones. Portions

of dried bone, muscle, and semi-decomposed muscle from four carcasses were minced with due precautions to prevent further contamination. "V-F" broth under vaseline, containing a little finely-divided sheep's heart, was seeded with 28 grammes of the material and incubated for ten days at 35 deg. C. Examination of the culture showed that at least four anaerobes were present. An endeavour is being made to isolate the toxicogenic organism in pure culture.

A guinea pig drenched with 2 c.c. of the culture fluid developed the syndrome which is characteristic of botulism in guinea pigs, i.e., vomition, paralysis, aphonia, loss of weight, &c., and died within 24 hours. A second guinea pig to which minced carrion had been fed at the rate of 5 grammes per day for five days, died from botulism on the sixth day.

Serological Tests.—Mr. Graham Edgar, of the Veterinary Research Station, Glenfield, kindly supplied the following antisera:—*B. botulinus* type A, type C, a polyvalent A, B, C, and *B. parabotulinus*. Toxin-antitoxin tests were carried out with these, with centrifuged culture and with culture filtrates.

A preliminary test, in which guinea pigs were inoculated with mixtures of 1 c.c. of supernatant fluid from centrifuged culture and equal amounts of each of the various antisera, indicated that the toxin present was that of *B. botulinus* type C, this being the only serum which gave complete protection. This finding was not borne out by subsequent tests, which are given in detail, and apparently resulted from the fact that the type C serum was the only one which was sufficiently potent to protect against the excessive amounts of toxin given.

On the 5th May, a Seitz filtrate of the culture (now fifteen days old) was made and tested for sterility. Chloroform was added as a preservative, and the toxin stored in the ice box. The minimum lethal dose of this toxin for a 250-300 gm. guinea pig was found to be 0.025 c.c.

The toxin was diluted with normal saline, and appropriate mixtures of this and the various antisera were made and incubated for one hour at 37 deg. C. The mixtures were then inoculated intramuscularly into guinea pigs, each receiving 2 c.c. The results are given in Table 2:—

TABLE 2.

Guinea Pig No.	Inoculation.	Result.
10	6 M.L.D. toxin	Dead 3 days
11	+ 1 c.c. *B. botulinus* type A antiserum	Dead 2 days
12	6 M.L.D. toxin	Survived
13	+ 1 c.c. *B. parabotulinus* antiserum	,,
14	6 M.L.D. toxin	,,
15	+ 1 c.c. *B. botulinus* polyvalent type A, B, C antiserum	,,
16	6 M.L.D. toxin	,,
17	+ 1 c.c. *B. botulinus* type C antiserum	,,
18	Controls	Dead 3 days
19	6 M.L.D. toxin	Dead 2 days

The toxin is neutralized by both *B. botulinus* type C and *B. parabotulinus* antisera (also by polyvalent serum containing type C antibodies) and is therefore that of *B. parabotulinus* which is known to be neutralized by type C as well as by its homologous serum, type C toxin being neutralized only by its homologous serum.

To obtain confirmation of this result, in view of the contradictory finding in the preliminary test with unfiltered toxin, a further test was carried out in which mice were substituted on account of shortage of guinea pigs. The M.L.D. of the filtered toxin for a 30 gm. mouse was found to be 0.01 c.c. The toxin-antitoxin experiment, the results of which are tabulated in Table 3, was carried out in a comparable manner to the previous test. The amount of inoculum in each case was 1 c.c. given intramuscularly.

TABLE 3.

Mouse No.	Inoculation.	Result.
6	5 L.M.D. toxin	Died 1 day
7	+ 0·5 c.c. *B. botulinus* type A antiserum	,,
8	5 M.L.D. toxin	Survived
9	+ 0·5 c.c. *B. botulinus* type A, B, C antiserum	,,
10	5 M.L.D. toxin	,,
11	0·5 c.c. *B. botulinus* type C antiserum	,,
12	5 M.L.D. toxin	,,
13	+ 0·5 c.c. *B. parabotulinus* antiserum	,,
14	Controls	Died 1 day
15	5 M.L.D. toxin	,,

This test confirmed the previous one. The organism isolated is therefore *B. parabotulinus*.

5. Literature Cited.

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Thrips Investigation.

I. The Seasonal Fluctuations in Numbers of *Thrips imaginis* Bagnall and Associated Blossom Thrips.

*By J. W. Evans, M.A.**

(From the Waite Agricultural Research Institute, University of Adelaide.)

The occurrence of thrips in plague numbers throughout the southern areas of Australia has been recorded at intervals during the past 25 years. *Thrips imaginis*, which inhabits flowers and blossom, is the important species concerned. These infestations occur in spring and early summer, and are associated with a marked reduction of the apple crop in these years. As a result of these losses, thrips play a part in influencing the State-wide fluctuation of the apple crop, a problem of great importance to the industry.

An investigation of thrips, in this respect, has been undertaken as a co-operative enterprise between the Council, the Waite Agricultural Research Institute (University of Adelaide), certain State Departments of Agriculture, and the Thrips Investigation League, and has been placed under the direction of the Chief Entomologist at the Waite Institute, Dr. J. Davidson (see page 216). The Thrips Investigation League is a body that was set up by fruit-growers, merchants, and others concerned in the fruit industry soon after the disastrous thrips year of 1931. Its objects are to stimulate the investigation of the thrips problem, and to collect funds to supplement those made available by research organizations studying that problem.

The present paper by Mr. Evans deals with the results of observations, obtained during the past year, on one aspect of the problem.—Ed.

Summary.

A study is being made of the seasonal fluctuations in numbers of *Thrips imaginis*, and associated blossom thrips, in the neighbourhood of Adelaide. A summary of the data obtained during a complete year from April, 1932—March, 1933, is presented. Throughout the year, daily records have been made of counts of the thrips populations of roses. During the spring, additional daily records were obtained of the thrips populations of other blossom. The purpose of this aspect of the investigation is the determination of the factors responsible for thrips infestations, by means of the correlation of the rises and falls of the populations with meteorological conditions.

A method by which the periods of generations of *Thrips imaginis* during any season can be calculated from data concerned with the development of the insect at different temperatures is given in an Appendix.

1. Introduction.

In order to obtain definite information regarding the factors responsible for thrips infestations, a study is being made of the seasonal fluctuations of natural populations of blossom thrips in the neighbourhood of Adelaide. This work will be carried on continuously during the course of the investigations. The data presented here comprise the results of the first year's observations from April, 1932—March, 1933 inclusive.

* An officer of the Council's Division of Economic Entomology, attached to the Waite Institute in connexion with the Thrips Investigation.

2. Sampling Technique.

Records of thrips populations are made in the following manner:— Samples of flowers from a plant are cut directly into a cylindrical cardboard box, which is closed with a tightly fitting lid. The box is taken into the laboratory, and its contents emptied into a large glass cylinder. This* has an open bottom, which rests on a sheet of paper, a perforated zinc tray inside, on which the blossom rests, and a close-fitting lid having a cotton wool pad in the centre. The outside of the cylinder is covered with black paper, from the top to the level of the tray. Before the flowers are put in, a few drops of turpentine are placed on the cotton wool, and an electric light, with the bulb close to the bottom of the jar, is turned on. About half-an-hour after the flowers have been put into the cylinder, the great majority of the thrips that were in them are found dead on the paper, only a few remaining in the blossom. The insects are transferred with a camel-hair brush to a small dish of dilute alcohol, separated into species, sexes, adults, and nymphs, and each group counted. The locality, date, and amount of blossom from the host plant are then recorded, together with details of the thrips population. In addition to scattered observations made in various localities during the year, several consecutive series were made during the spring, and one consecutive series has been carried on during the whole year. In all, nearly a thousand separate records have been kept.

3. Population Records.

(*a*) Rose Series.

Since the beginning of April, 1932, sample counts have been taken of the thrips populations of roses growing in a garden adjacent to the Waite Institute. For eight and a half months of this period, twenty roses at the same stage of development were picked daily from one of three hedges of Cecil Brunner roses growing in this garden, and their thrips inhabitants were recorded. For three and a half months during the winter, these roses were not available, and from 7th July until 23rd August, the samples were taken from such scattered roses of various varieties as were present in the garden. Towards the end of August, a bush of Fortuniana roses came into flower, and from the 26th of this month until 31st October, records were regularly taken from it. *Thrips imaginis* was the only species present in every sample; the others in order of persistence were *Haplothrips victoriensis* Bagnall, *Isoneurothrips australis* Bagnall, *Thrips tabaci* Lind, and *Frankliniella insularis* Franklin. Six other species occurred occasionally in small numbers, the most prevalent being *Physothrips kellyanus* Bagnall, in winter and spring, and *Desmothrips davidsoni* Morison, during the summer.

Apart from *imaginis*, the species mentioned above play no appreciable part in outbreaks, but their fluctuations in numbers are being followed for comparative purposes, and to add to our knowledge of thrips in general. Although the method of sampling may remain standardized throughout the season, the number and kind of flowers in the locality under observation are changing all the time. Therefore, samples of host plants examined for the purpose of determining the seasonal

* Being described in the *Bull. Entom. Res.*, 24 : 1933.

fluctuations in the numbers of any species cannot contain a constant proportion of the available numbers in any selected locality. It is, however, believed that, in the case of *imaginis* and *victoriensis*, the numbers recorded in roses represent a fair sample of the adult population, as these species prefer roses to other flowers. Roses are not the favorite food plant of *tabaci, australis*, and *insularis*. Therefore, these species are represented in counts from roses only when they are distributed generally in very large numbers. Ageratum, carnations, and chrysanthemums are among the favoured hosts of *tabaci;* myrtles and eucalypts of *australis;* and carnations, scabious, and geraniums of *insularis*. Hence a sudden influx of any of these species of thrips into roses need not necessarily signify the emergence of a brood; it may equally mean that some nearby chrysanthemums, carnations, or myrtles have finished flowering, and that their thrips inhabitants have accordingly been forced to seek such other food as is available. Conversely, the absence of these species from roses is no indication that there are no thrips about at the time, as it is generally possible to find small numbers of all the three species referred to above in their principal host plants, during any month of the year.

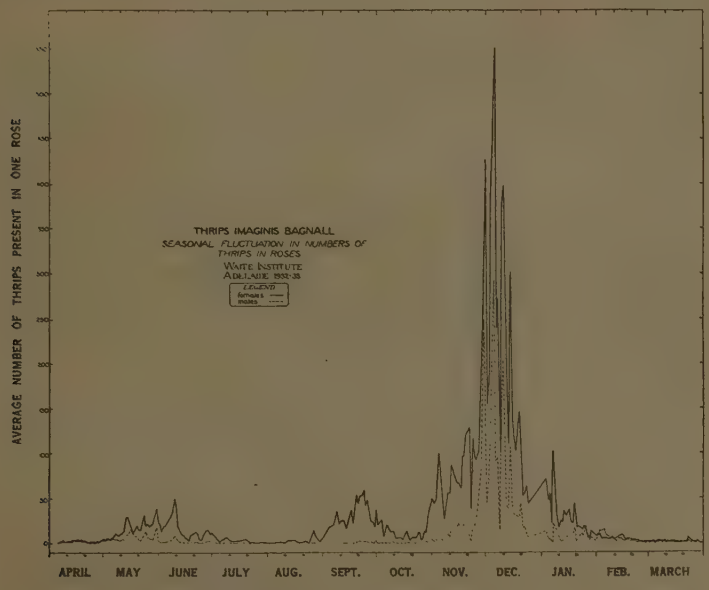

FIG. 1. Showing the seasonal fluctuation in thrips in roses at the Waite Institute, 1932–33.

Figure 1 represents the average daily numbers of male and female *Thrips imaginis* in one rose, over a period of twelve consecutive months. The chart is constructed from 274 daily records. The numbers of nymphs found have not been plotted, as roses are evidently not favorable breeding sites. Possibly the hardness of the calyces and flower stalks prevents the insertion of the insect's ovipositor.

The chart gives an accurate picture of the fluctuations of generations, with the exception of the latter half of October, when the Fortuniana roses were past their prime and few in number. Other records made at this time indicate the second spring generation emerged two weeks earlier than is shown in the chart. In a previous publication,* attention was drawn to the fact that, during the autumn, the weather resembles that of spring, and that these two periods afford optimum conditions for the increase of thrips. That the conditions during April were more favorable for reproduction than in March is shown in Fig. 1 by the rise in numbers in May. (In March, the average mean daily temperature was 20° C., and 160 points of rain fell. In April, the average mean daily temperature was 15.2° C., and 550 points of rain fell.) The three waves of increasing emergence in May are followed by a further increase in June. This is succeeded by a drop during July and August. At the end of the latter month, and during September, the emergence of the first spring generation took place. During October, the numbers dropped on account of the cold weather, and it was not until November and December that any considerable increase occurred. The numbers again fell in December, reaching a low level, which was maintained until the end of the period under consideration.

The sex ratio did not remain constant throughout the year. In April, the sexes were approximately equal. In May, the females outnumbered the males, and again, to a greater extent, in June and July. The spring emergence was almost entirely composed of females. In November, the proportion of males increased, and from December until the end of March the sexes were approximately equal.

Two types of parthenogenesis have been shown to occur among thrips; (*a*) thelyotokous parthenogenesis, in which eggs from unfertilized females give rise only to female offspring, as with *T. tabaci* in the neighbourhood of Adelaide, where males have not been found; (*b*) arrhenotokous parthenogenesis, in which eggs from unfertilized females give rise only to males (fertilized eggs produce only females). A third type has been recorded by Raymond† with *Physopus pallipennis* Uzel, in which thelyotokous parthenogenetic generations alternate with sexual generations.

Thrips imaginis belongs to the second type. The first autumn generation appeared in May, and was the progeny of the relatively small numbers of thrips living in April. It was closely followed by the second generation which emerged in June. The male line followed the female line during both generations, but at a progressively lower level (Fig. 1). The majority of the eggs laid by females of the first generation must have been fertilized, and hence gave rise to a preponderance of females.

There is no true resting stage, merely a delayed development during the winter, the spring emergence being composed of offspring of the second autumn generation. In the autumn, the males started from stock composed of approximately equal numbers of the sexes, and the proportion of males to females steadily decreased. In the spring, the proportion of males increased, following on a generation consisting largely of females, until once more, in the summer, a balance was established between the sexes.

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* Council for Scientific and Industrial Research, Pamphlet 30, 1932.

† *Raymond, G.* "Contributions à l'étude des Thrips attaquant les oeillets." *Ann. Soc. Linn. Lyon* **62**: 1923.

For the purpose of this paper, the length of a generation is defined as the period required for the complete development of an individual from the time the egg is laid until the resulting adult lays eggs. Those individuals that reach adult stage during this period of time are considered as comprising a generation. In the Adelaide district, where low winter temperatures are seldom recorded, eggs may be laid and development continue throughout the year, so that actually there is a succession of generations. (The average mean daily temperature for June and July, for the last eight years, recorded at the Waite Institute is 10.9° C.)

For convenience, a generation may be considered as commencing on a date where a marked increase in the numbers of thrips (the result of favorable meteorological conditions), follows a period of a relatively stable though small population. Commencing with this selected date, the duration of a generation can be calculated approximately. One method of doing this is discussed in the Appendix to this paper. The beginning of a new generation may also be determined from analysis of samples of the population, since a change in the relative abundance of the sexes, or a sudden rise in numbers, indicates a new generation.

(*b*) Cape Weed and Salvation Jane Series.

In order to follow the progress of the thrips population during the spring, and to serve as checks on the counts made from roses during this critical period of the year, daily counts were made of thrips present in the flowers of Salvation Jane (*Echium plantagineum*), and Cape weed (*Cryptostemma calendulaceum*), both introduced weeds known to be attractive to thrips. With both species, 50 flowers were picked every morning from the centre of large patches of the weeds growing near the Waite Institute. The numbers of thrips in the samples indicate only approximately the populations present at any time, since the numbers of blossoms present in the area did not remain constant. The thrips increased to a maximum at the middle of the period of flowering, and then decreased. It might be supposed that counts taken when the flowers were beginning to fail would show a disproportionately high number of thrips, the available numbers being crowded into a reduced quantity of blossoms. It is probable, however, that a reduction in blossom produces a corresponding reduction of the attractiveness of the area of weed for thrips, so that the two factors may balance each other.

The charts (Figs. 2, 4, and 5) serve to demarcate the generations, and illustrate the effect of increasing temperatures in shortening the length of the generations.

(*i*) *Cape Weed Series.*—Fig. 2 represents the progress of the population of *Thrips imaginis* in Cape weed flowers. It comprises two complete generations, the first commencing on 26th August and ending on 8th October, the second emerging on 10th October and lasting until 4th November. The drop in numbers after the latter date is due to the food plant dying out with the onset of dry weather. The two generations can be separated by the relatively greater height of the male line after 10th October.

In a previous publication, it was suggested that one of the causes to which thrips outbreaks may be ascribed is the alternation of very hot days with cold days in the spring, the hot days having the effect of

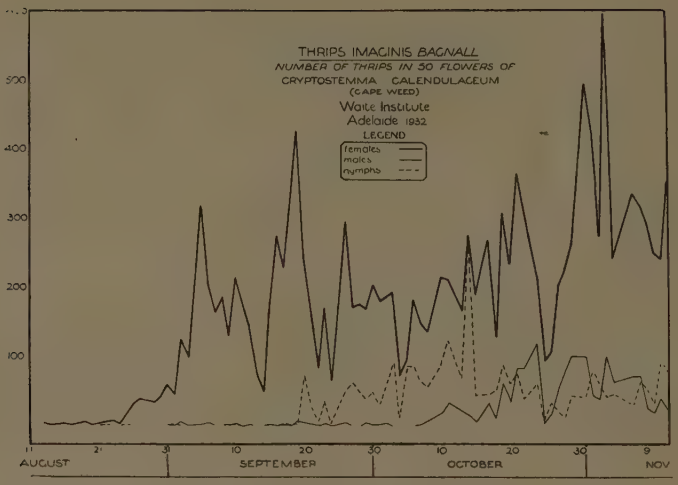

FIG. 2. Showing the numbers of thrips in 50 flowers of Cape Weed in various months.

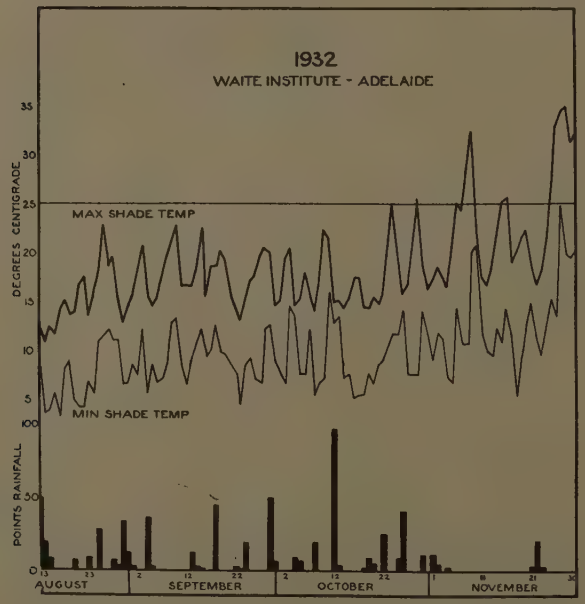

FIG. 3. Chart showing the meteorological conditions during the observations of thrips populations.

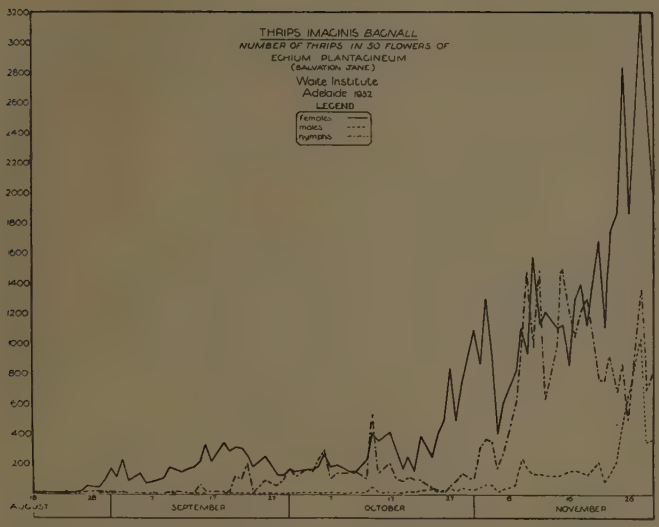

FIG. 4. Showing the number of thrips in 50 flowers of Salvation Jane in various months.

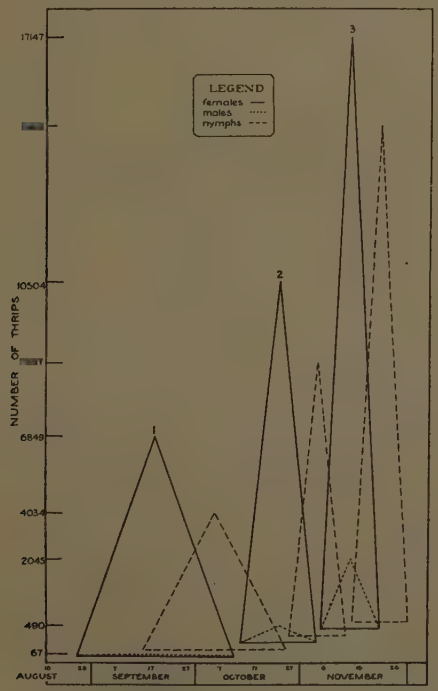

FIG. 5. Analysis of the data presented in Fig. 4. (For explanation see text.)

bringing up together large collections of individuals which otherwise would have emerged on separate days. Figure 2 shows clearly how several separate waves of emergence may follow each other consecutively over a long period when the weather is cool. A few hot days early in September would have had the effect of producing less waves, but much bigger ones. The result of this synchronization would show up in succeeding generations.

Three separate waves will be noticed in the first generation. In the second generation, the first wave is distinct, being separated from the succeeding ones by a deep depression between 21st and 31st October, which can be correlated with the depression between 5th September and 16th September, and is not the direct result of prevailing weather conditions. By comparing Fig. 2 with the meteorological conditions (Fig. 3), it will be seen that the extremes of temperatures are not correlated with rises or falls in the numbers of thrips. This correlation is not evident until a succession of days of high temperature (above 25° C.) have brought about an overlapping of waves or generations, so that large numbers of individuals emerge directly the temperatures rises to a sufficiently high point.

(ii) *Salvation Jane Series.*—Fig. 4, representing the spring population of *Thrips imaginis* in Salvation Jane flowers, comprises three complete generations and the commencement of a fourth. (Three of these generations are represented in a diagram, drawn to scale—Fig. 5.) The fourth generation, being incomplete, is omitted. The height of each triangle represents the total number of thrips, whether males, females, or nymphs, that were found in the samples during the period of the generation involved. The base line represents the duration of the generations. It will be noticed in Table I. that the progeny of each generation consists of less individuals than its forbears and its resulting adults. This is explained by the fact that, although a large proportion of the nymphs on a plant of Salvation Jane congregate on the flowers, numbers also feed on other parts of the plant, wherever shelter is obtainable. The adults, on the other hand, concentrate on the flowers.

(c) Other Records.

In addition to the series of records presented in the preceding paragraphs, other series were obtained. These will be useful for comparison with similar records for other seasons, and for determination of the plants in which the first spring generations of *T. imaginis* can multiply prior to the blossoming of apple trees. A summary of the data obtained is given in Table II. *T. imaginis* was present in all the samples recorded below. Entries have been made in the last column of the table only if this species was scarce (less than an average of one insect to every two flowers), when the series commenced.

With the assistance of orchardists at Kersbrook and Balhannah, records were kept of the thrips populations infesting the principal varieties of apples grown in these districts. In both localities, 50 blossoms (approximately) were picked at random from each variety in flower at the time, and posted to the laboratory, where the thrips were isolated, sorted, and counted. The samples were taken twice a week. No difference was noted in the relative attractiveness to thrips of the different varieties.

TABLE I.—NUMBERS OF *T. imaginis* IN THE FLOWERS OF SALVATION JANE DURING THE GENERATION PERIODS GIVEN IN COLUMN 2, AND METEOROLOGICAL DATA FOR THE CORRESPONDING PERIODS.

Generations.	Length of Generations.	Total Rainfall in Inches.	No. of Days Rain Fell.	Mean Daily Average Temperature (° C.).	Total Population.
1	27.8.32–11.10.32	2·8	34	13·1°	67 ♂ 6,849 ♀
Nymphs	15.9.32–26.10.32	2·2	30	11·1°	4,034
2	12.10.32–4.11.32	2·3	16	13·9°	490 ♂ 10,504 ♀
Nymphs	27.10.32–12.11.32	·3	7	17·1°	7,997
3	5.11.32–22.11.32	·2	16	17·9°	2,046 ♂ 17,147 ♀
Nymphs	13.11.32–30.11.32	·3	7	21·2°	14,618
4	23.11.32–	·1	3	26·3°	3,229 ♂ 16,201 ♀

TABLE II.—SUMMARY OF POPULATION RECORDS OF *T. imaginis*, MADE IN THE SPRING OF 1932, PRIOR TO OCTOBER.

Blossom.	Locality.	Samples Taken.		No. of Samples.	Nymphs first Recorded.	Increase in Nos. first Recorded.
		From—	To—			
Almond ..	Adelaide	15th July	1st Sept.	24	1st Sept.	29th Aug.
Prunus Pissardii	,,	9th Aug.	9th Sept.	15	9th Sept.	26th Aug.
Prunus Mume	,,	11th Aug.	25th Aug.	8	..	22nd Aug.
Plum ..	,,	29th Aug.	28th Sept.	17	16th Sept.	..
Pear	,,	21st Sept.	10th Oct.	9	30th Sept.	..
Acacia spp.	,,	2nd Aug.	19th Sept.	4	14th Sept.	14th Sept.
Plum ..	Blackwood	1st Aug.	19th Sept.	17	12th Sept.	7th Sept.
Cherry ..	,,	12th Sept.	11th Oct.	5	11th Oct.	..
Apricot ..	,,	11th Sept.	14th Sept.	3	..	12th Sept.
Pear ..	,,	24th Aug.	11th Oct.	9	19th Sept.	12th Sept.
Acacia normalis	,,	16th Aug.	1st Sept.	3	1st Sept.	1st Sept.
A. pycantha	,,	24th Aug.	10th Sept.	4	10th Sept.	..
A. armata	,,	24th Aug.	10th Sept.	4	..	..
A. obliqua	,,	24th Aug.	10th Sept.	5	..	Never abundant
A. cultiformis	,,	1st Sept.	..	1	1st Sept.	..
A. sophora	,,	1st Sept.	..	1	1st Sept.	..

The data presented in Table III. are given to show the small thrips populations present in apple blossom during the past spring. The orchard at Balhannah suffered severely from infestations during the 1926 and 1931 season.

TABLE III.—AVERAGE NUMBER OF *Thrips imaginis* IN ONE APPLE BLOSSOM, AND QUANTITY OF BLOSSOM EXAMINED, OCTOBER-NOVEMBER, 1932.

Balhannah.			Kersbrook.		
Date.	No. of Thrips per Blossom.	No. of Blossoms Examined.	Date.	No. of Thrips per Blossom.	No. of Blossoms Examined.
4th October ..	0·3	155	3rd October ..	0·7	137
6th October ..	0·45	193	6th October ..	1·5	170
7th October ..	0·4	49	..	..	..
11th October ..	2·25	289	10th October ..	1·0	219
14th October ..	0·9	290	14th October ..	2·1	324
17th October ..	2·3	275	..	..	..
19th October ..	1·5	39	19th October ..	2·6	374
20th October ..	0·4	297	21st October ..	1·6	323
24th October ..	0·9	294	24th October ..	9·8	467
27th October ..	2·6	294	..	..	..
31st October ..	3·6	198	31st October ..	14·0	286
3rd November ..	2·9	63	3rd November ..	11·8	89

4. Discussion.

The main purpose of this paper is to put on record certain observations made during the course of the investigation in 1932-33. When similar data have been accumulated over a longer period, an attempt will be made to analyse fully the information thus obtained.

The records enable one to correlate fluctuations in thrips populations with meteorological conditions. It is evident that the important factors regulating their numbers, and hence the occurrence of plague infestations, are the weather conditions prior to, and during, an infestation.

The control exerted by parasites or predators, at any time, or in any place, appears to be of so little account as to be of no more than of academic interest.

That the meteorological conditions responsible for outbreaks are not small local departures from the normal, but climatic variations on a big scale, is evident from the fact that outbreaks of thrips occur at the same time over immense areas of Eastern and Western Australia. In these areas, the outbreaks may vary in intensity in different places, due to such factors as elevation, hence greater rainfall, or to a profusion or lack of breeding sites.

It is the opinion of the writer that the numbers of individuals comprising the first spring generation determine the possibilities of a subsequent infestation. The numbers present in this generation are dependent especially on the meteorological conditions during the preceding four months.

An examination of the meteorological data for past years has shown that thrips outbreaks in the spring have invariably followed winters of abnormally heavy rainfall. The total rainfall recorded at the Waite Institute from April to August, 1932, was 20 inches; the average rainfall recorded at Adelaide for the same months over 78 years is 12.7 inches. Thus, on the assumption that a heavy winter rainfall is favorable to thrips increase, the spring of 1932 can be regarded as one in which a thrips outbreak was possible.

From the data presented in Figs. 1, 2, and 4, it is apparent that the emergence of the first spring generation was spread over a long period; hence the appearance of the second generation was delayed. Also, as shown in all three figures, and in the numbers given in Table I., the increase in the numbers of thrips of the second generation compared with its predecessor was negligible.

Owing to the cold wet weather prevailing during October, the length of the second generation was protracted, the third generation not appearing until November, and it was not until the appearance of the fourth generation, at the beginning of December, that any appreciable increase in thrips was evident. This increase was due more to overlapping waves of emergence, the result of high temperatures, than to actual multiplication as the result of reproduction.

If a chart similar to Fig. 1 had been constructed for the 1931 season, the maximum value of the population curve at the end of October would have been four times that of the maximum value reached in 1932.

5. Notes on Associated Blossom Thrips.

(*a*) *Thrips tabaci.*—This species, of which only females have been found in South Australia, is present in small numbers throughout the year, but during the twelve months over which records have been kept, it has never become very numerous. A statement made on page 30 of C.S.I.R. Pamphlet 30, to the effect that *T. tabaci* does not begin to reproduce until the end of October, should be modified, as in each of eight sample counts from ageratum, taken between the middle of August and the end of October, not only were individuals of the species found in comparatively high numbers, but there were also nymphs in every sample taken. It is most abundant and widely distributed during the summer months.

(*b*) *Isoneurothrips australis* has two periods of increase during the year, namely, autumn and spring. The autumn increase carries on longer than in the case of *T. imaginis,* and the spring one begins earlier. During the periods of favorable meteorological conditions, *I. australis* is distributed in a wide range of host plants, but in the summer, with the exception of stray individuals, it is confined to *Eucalyptus* blossom.

(*c*) *Frankliniella insularis* is only abundant during the summer, and was absent from all records made between May and November. During December, January, February, and March, it is widely distributed over a wide range of plants, of which carnations are the most favoured. Neither this species nor *T. tabaci* confine their feeding to blossom to such an extent as *T. imaginis;* they are frequently found feeding on leaves.

(*d*) *Haplothrips victoriensis* is abundant from the beginning of December until the end of March, is present in reduced but quite high numbers, from April to June, and persists throughout the winter and spring at a low level of abundance.

(*e*) *Other Species.*—The species mentioned above have been selected for notice since they occur persistently during certain months in blossom with *T. imaginis.* None of them has such a wide range of hosts as *T. imaginis,* and it may be that none of them has such a short life-cycle. Six other species have occurred in the samples taken, but little information has been gathered concerning their range of host plants or season of abundance.

6. Conclusions.

The data presented in this paper consist of records of field observations. Correlation of meteorological records with population fluctuations will indicate the factors influencing the rise and fall in thrips abundance. Before an accurate analysis of the effect of the different factors involved can be attempted, laboratory experiments will have to be carried out to elucidate many points.

Although the records given here have been made in South Australia, the picture of the seasonal fluctuations in numbers of *Thrips imaginis* they present will be found to be very similar to the conditions obtaining elsewhere in temperate Australia, excepting during the winter. In this season, in the colder parts of Victoria and New South Wales, it is probable that there is a true dormant period, or hibernation, rather than a slow development. The effect of low winter temperatures and rainfall, in this respect, has yet to be investigated.

7. Acknowledgments.

The author is indebted to Dr. J. Davidson for considerable assistance in the work described, and for help in the preparation of this paper. Acknowledgment is also due to Mr. N. Wicks, of Balhannah, and Mr. H. E. Stephenson, of Kersbrook, for their co-operation in the matter of taking samples of apple blossom for recording their thrips population.

Appendix.

METHODS OF CALCULATING THE DURATION OF GENERATIONS OF *THRIPS IMAGINIS*.

In a previous publication (C.S.I.R. Pamphlet 30, 1932), data were presented in connexion with the development of *Thrips imaginis* at various constant temperatures, and from this data a temperature-development curve was calculated for the complete development of an individual from egg-laying to adult stage.

It has been shown by other workers that the rate of the development of the insect embryo may have a different velocity to that of the succeeding developmental stages. Accordingly, from the available data, separate curves (Fig. 6) have been constructed for two stages.

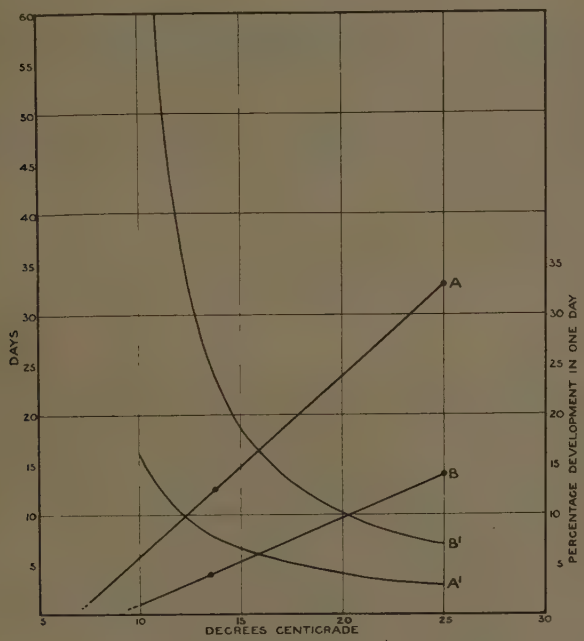

FIG. 6. Temperature-development curves and temperature-velocity curves of *Thrips imaginis* for the periods egg-laying—egg-hatching (A), and egg hatching—egg-laying (B.)

The temperature-development curves have been plotted in accordance with the formula $d = \frac{K}{t - c}$ where d = the developmental period in days; t = temperature in degrees Centigrade; c = the developmental zero, and K = the thermal constant. Using the data from observations at two different constant temperatures, the developmental zero for each stage was calculated from the formula $c = \frac{dt - DT}{d - D}$

For the period, egg-laying (E.L.) to egg-hatching (E.H.), the developmental zero is 6·6° C., and for the period egg-hatching to egg-laying, 9° C. The points plotted on the E.H. to E.L. curve represent not merely the periods to adult stage, but include also the period until the eggs are mature and oviposition can take place.

Thus, at 13·5° C., where the period E.H. to adult is 23 days, two extra days are allowed for the maturation of the eggs. At 25° C., the period E.H. to adult is six days, and one extra day is allowed. The two periods are both based on observations. For the period E.L. to E.H., the thermal constant is 55·2° C., and for the period E.H. to E.L., 112·5° C.

The periods of the generations obtained by this method are approximate only, since they are derived from observations on the development of the insect at constant temperatures, and such conditions do not occur in nature.

Closest correlation between the periods of calculated and observed generations might be expected when the calculations are based on medial temperatures, that is, those temperatures whose range lies on the straight line portion of the velocity curve, since development will not be influenced by retardation resulting from high temperatures, nor by the lag effect consequent on low temperatures.

It would seem that with *T. imaginis* the developmental zero is close to the point where the velocity curve intersects the temperature axis. The periods of generations, calculated by summation of effective mean temperatures, until the thermal constant is reached, are almost identical with corresponding periods arrived at by averaging the mean daily temperatures, and referring the resulting mean temperature obtained to the development curve (Fig. 6).

In Table IV., column 8, the generation periods are calculated by the latter method, those in column 9 by the former. No claims are made that calculations of the periods of generations based on this method are strictly accurate, but they serve to define their approximate duration.

TABLE IV.—CALCULATED LENGTH OF GENERATIONS OF THRIPS IMAGINIS FROM APRIL TO DECEMBER, 1932.

Generations.	Date of commencement of generations (E.L.).	Eggs—hatch (E.H.).	Average mean temperature in ° C. E.L. to E.H.	Average mean temperature in ° C. E.H. to E.L.	Total rainfall in points during each generation.	Average number of thrips in one rose.	Length in days of complete generation.	Length in days of corresponding generations, calculated by summation of effective mean temperatures.
1	18th April	26th April	14·7	15·9	96	3, ♂ 6, ♀	26	23
2	14th May	20th May	15·9	14·9	288	6, ♂ 20, ♀	26	28
3	9th June	24th June	10·5	11·0	1,083	1, ♂ 8, ♀	78	78
4	26th Aug.	4th Sept.	12·8	13·3	250	1, ♂ 19, ♀	36	35
5	1st Oct.	10th Oct.	13·1	13·6	259	12, ♂ 75, ♀	32	34
6	3rd Nov.	9th Nov.	18·0	18·0	30	80, ♂ 187, ♀	19	20
7	22nd Nov.	26th Nov.	19·8	22·1	12	138, ♂ 216, ♀	13	15
8	4th Dec.	8th Dec.	19·9	20·6	10	30, ♂ 71, ♀	14	15
9	18th Dec.	22nd Dec.	21·7	17·2	26	8, ♂ 37, ♀	18	16

May 14th has been taken as a suitable starting point from which to calculate the periods of the generations. Reference to Fig. 1 in the main part of the paper, will show that the first appreciable increase in the numbers of thrips was recorded on this date. From this date, the length of the previous generation has been calculated, and the number of generations which developed until the end of the calendar year. From November onwards, high temperatures may exert a harmful effect. Above 25° C., the velocity of development changes and proceeds at a slower rate up to 30° C. Above that point, the effect of high temperatures has not been investigated, but there can be no acceleration, and in all probability the velocity will be considerably retarded. Consequently, the figures given for the lengths of the last four generations are probably smaller than would be the case had it been possible to make accurate corrections for degrees of temperatures recorded over 25° C.

In Table V., the engths of the generations actually observed during the past spring are given.

TABLE V.—OBSERVED PERIODS OF GENERATIONS OF THRIPS IMAGINIS FROM AUGUST TO NOVEMBER, 1932.

Generations.	Roses.		Salvation Jane.		Cape Weed.	
	Beginning of generations.	Length in days.	Beginning of generations.	Length in days.	Beginning of generations.	Length in days.
1	26th Aug.	48	27th Aug.	46	26th Aug.	45
2	13th Oct.	25	12th Oct.	23	10th Oct.	25
3	7th Nov.	15	4th Nov.	18	4th Nov.	..
4	22nd Nov.	..	22nd Nov.	..	..	..

Both calculations and observations indicate that the spring emergence or first spring generation commenced on 26th August, and that the fourth spring generation first appeared on 22nd November, but the calculated periods of the first two generations differ considerably from the observed. The influence of rainfall on the environment of the insect is little understood; hence no explanation can yet be offered to account for this divergence. A comparison of Table IV. with Fig. 1 will show that the calculated duration of the first autumn generation coincides with the observed duration. The same correlation is evident with the second autumn generation, which extends through the winter. In the locality where these observations have been made, it is evident that a slow development of the insect in its different stages takes place throughout the winter. It is probable, however, that in parts of Victoria where winter temperatures frequently fall below the developmental zero, conditions approaching true hibernation may obtain.

The Composition of Different Regions of Mounds of *Eutermes exitiosus* Hill.

*By F. G. Holdaway, M.Sc., Ph.D.**

Summary.

In the development of standard laboratory colonies of *Eutermes exitiosus* Hill, it has been necessary to decide on the most suitable kind of mound material to be used. Analyses of five mounds have served as a basis for studying the variation in composition of the three regions of the mound. The variation in composition of the inner wall is small, and is only slightly more than that of the nursery. Since the nursery provides only a small amount of material while the inner wall provides a large bulk, the inner wall has been decided on for laboratory colonies.

1. Introduction.

The study here reported forms one phase of the development of standard laboratory colonies for testing timbers for relative resistance to "white ant" (termite) attack, and for studying treatments for preventing attack. The aim of the work is to develop laboratory colonies which are standard as regards population of termites and amount of nest material. These will be maintained in the laboratory under satisfactory controlled physical conditions which are being determined. Preliminary inquiries along these lines have been reported elsewhere by Mr. G. F. Hill (1930), whose initial studies have paved the way for those now in progress.

Eutermes exitiosus is considered by Hill (1932A) to be one of the most important economic species of termite in South-Eastern Australia. In passing, it is of interest to note that this species does not contain the cellulose-digesting Protozoa which Cleveland (1923) formerly considered were essential for the digestion of wood by wood-eating termites. Bacteria are present, and possibly they perform for *Eutermes* the function performed by Protozoa in other species.

The mound of *Eutermes* is composed of three regions with fairly definite limits, (i) the outer wall averaging about 3 inches in thickness and composed of earthy material with large galleries, (ii) the inner wall, tough and woody, 5 or 6 inches in thickness, with a lower proportion of earthy material and a higher proportion of organic matter, and (iii) the "nursery,"† which occupies the centre of the mound and extends below the ground level. (*Vide* Plate 1.) It is composed of brittle woody material forming the thin walls of an intricate system of galleries. The average dimensions of mounds of the size used in this work are as follows. The average is based on seventeen mounds:—

Horizontal Dimensions (at ground level).	Height.	Outer Wall.	Inner Wall.	Nursery.	
				Vertical Dimensions.	Horizontal Dimensions.
3′ 4″ x 3′ 7″	16″	3·5″	5·5″	13″	x 14″

* An officer of the Division of Economic Entomology.

† The name "nursery" is used for this region of the mound, since, in general the queen is located there and there eggs are laid and juveniles reared. Nevertheless, the nursery is not restricted to these uses. Workers and soldiers, and nymphs and winged forms too, at certain times of the year, particularly in the cold weather, congregate there in large numbers.

PLATE 1.

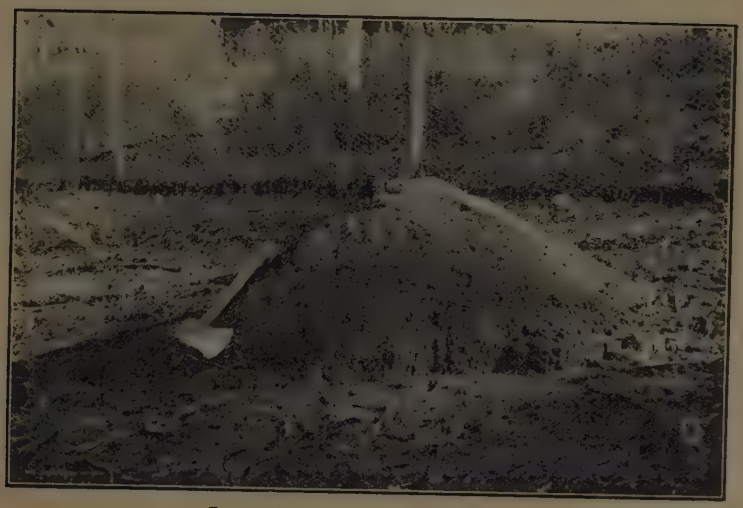

FIG. 1. Mound of *Eutermes exitiosus*.

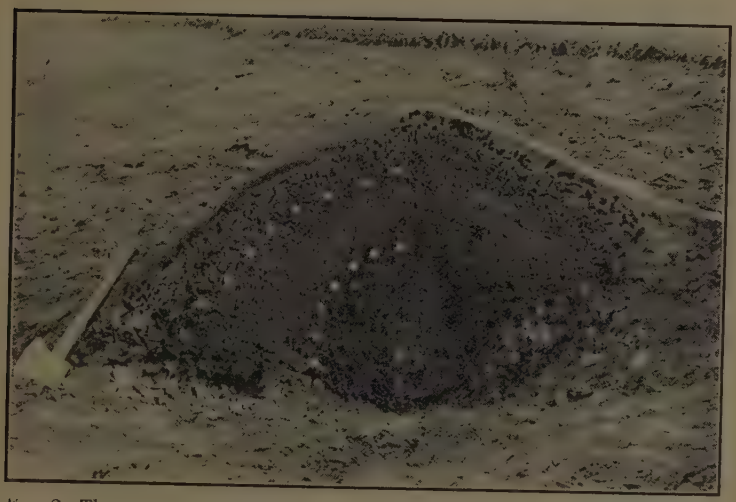

FIG. 2. The same mound cut vertically to show the three regions, outer wall, inner wall, and nursery. The limits of the regions are indicated on the left side of the mound by means of white-headed nails. The photo also shows that the nursery extends below ground level.

Details of the procedure developed for setting up laboratory colonies will be given later. For the present, all that it is necessary to mention is that a known amount of termites is placed in a quart jar with definite amounts of wood and nest material of known moisture contents. There is a certain amount of food material available in the mound for the termites, and as the composition of the different regions is different, it has been necessary to determine the most satisfactory kind of mound material to use. Further, as the colonies are to be as standard as is practicable, it is necessary to use mound material which is fairly constant in composition and to know the degree of variation in its composition.

2. Analysis of Mounds of *Eutermes exitiosus*.

Five mounds of the size usually used to provide both mound material and termites for laboratory colonies were selected in a variety of situations in the neighbourhood of Canberra from which mounds are usually collected. Particulars of these mounds are given in Table 1.

Table 1.—Particulars of Mounds Used for Analysis.

Number of Mound.	Dimensions.		Aspect.	Slope.	Soil.	Remarks.
	Horizontal.	Vertical.				
1	3′ 8″ x 3′ 10″	15″	N.W.	Slight ..	Gravelly	
2	3′ 3″ x 3′ 8″	17″	N.N.W.	Moderate	Grey shale	Mound against stump of tree
3	3′ 4″ x 3′ 8″	22″	E.N.E.	Slight ..	Grey shale tending to yellowish	Butt of tree incorporated in mound
4	3′ 4″ x 3′ 6″	14″	N.N.W.	Moderate	Brown shale	Mound on ridge. Nest of meat ants *Iridomyrmex detectus* Sm. near edge of mound. Samples obtained from opposite side
5	3′ 3″ x 3′ 8″	19″	N.N.E	Moderate	Yellowish brown gravel	Fairly open surroundings. Thick, friable, outer wall

Portion of each region of each mound was broken up and freed from termites. Samples of each, 3 lb. in weight, were then forwarded to the Waite Institute, Adelaide, for analysis. (The total nursery material suitable for analysis usually weighed a little less than 3 lb.) The results of the analysis, made by Mr. C. S. Piper, are given in Table 2. The percentage of inorganic material is obtained by subtracting the percentage of organic material from 100.

In Table 3, the variation in composition of the different regions is given in terms of the coefficient of variation $\left(\frac{\text{Standard Deviation}}{\text{Mean}} \times 100\right)$.

TABLE 2.—ANALYSIS OF MOUNDS OF *Eutermes exitiosus*.

(*All results expressed on oven-dry basis.*)

Mound No.	Region.	Inorganic Material.	Organic Material (Loss on Ignition).	Nitrogen.	Organic Carbon.
		%	%	%	%
1	Outer wall ..	52·14	47·86	0·349	25·3
	Inner wall ..	20·5	79·50	0·550	43·7
	Nursery	14·22	85·78	0·631	47·3
2	Outer wall ..	52·9	47·1	0·31	25·3
	Inner wall ..	14·2	85·8	0·49	47·9
	Nursery	11·0	89·0	0·58	49·9
3	Outer wall ..	65·9	34·1	0·27	17·3
	Inner wall ..	15·0	85·0	0·575	47·5
	Nursery	6·2	93·8	0·74	52·8
4	Outer wall ..	65·3	34·7	0·27	18·3
	Inner wall ..	8·6	91·4	0·69	50·9
	Nursery	11·0	89·0	0·75	51·1
5	Outer wall ..	81·6	19·4	0·135	7·5
	Inner wall ..	16·8	83·2	0·53	46·1
	Nursery	12·9	87·1	0·64	48·9

TABLE 3.—COMPARISON OF THE VARIATION IN COMPOSITION OF DIFFERENT REGIONS OF MOUNDS OF *Eutermes exitiosus*.

Region.	Component.	Coefficient of Variation $\left(\frac{\text{Standard Deviation}}{\text{Mean}} \times 100\right)$.
Outer wall	Organic material	31·8
	Organic carbon	39·1
	N_2	29·9
Inner wall	Organic material	5·1
	Organic carbon	5·6
	N_2	13·6
Nursery	Organic material	3·4
	Organic carbon	4·2
	N_2	11·0

It will be seen that there is least variation in the nursery. The inner wall shows a variability only slightly greater than that of the nursery, while the maximum variation is found in the outer wall. The nursery, with its open structure and thin walls, provides very little bulk. It could thus provide nest material for only a small number of laboratory colonies. The inner wall, on the other hand, provides a much greater bulk. This fact and the fact that the variation in composition is very little greater than that of the nursery have led to the decision to utilize the inner wall for laboratory colonies.

3. The Lignin and Cellulose Content of the Three Regions of a Mound of *Eutermes exitiosus*.

Since lignin apparently has no food value for termites (Cleveland 1925) and is thus apparently excreted unaffected by the digestive juices, the lignin content of the different regions of a mound should give an indication of the proportion of excrement in each region.

The three regions of mound No. 1 have been analysed for lignin, cellulose, and total pentosans by Mr. W. E. Cohen, of the Division of Forest Products. An account of this analysis is given elsewhere (Cohen 1933). The results, Tables 4 and 5, show that the lignin content is highest in the nursery, whilst there is also a high lignin content in the inner wall. The proportion of excrement used in the construction of the nest is thus highest in the nursery and lowest in the outer wall.

Table 4.—Results of Analysis of Mound No. 1 Expressed as Percentages of Oven-dry Weight of Original Material.

Location of Samples.	Total Combustible Matter.	Amount Soluble in 0·5 per cent. NaOH.	Cellulose.	Lignin.	Ratio Lignin : Cellulose.	Total Pentosans.
Outer wall ..	48·3	36·9	2·4	11·5	4·8	4·7
Inner wall ..	79·9	43·6	5·6	23·8	4·3	8·0
Nursery ..	86·0	46·1	7·3	27·0	3·7	7·2

Table 5.—Results of Analysis of Mound No. 1 Expressed as Percentages of Oven-dry Combustible Material.

Location of Samples.	Cellulose.	Lignin.	Total Pentosans.
Outer wall	5·0	23·8	9·7
Inner wall	7·0	29·8	10·0
Nursery	8·5	31·4	8·4

The presence of cellulose in a more or less uniform proportion to lignin in all parts of the mound suggests that a proportion of cellulose is undigested by the termites and is passed to the exterior with the lignin. *Eutermes exitiosus* is a wood-feeding termite. The ratio of lignin to cellulose in its food would therefore be about 2 : 1, and this ratio has been changed by digestion of cellulose to 1 : 4. (A similar change from a lignin : cellulose ratio in camphor wood of about $2\frac{1}{2}$: 1 to a ratio of about 1 : 4 in the nest is recorded by Oshima (1919) for *Coptotermes formosanus*.) A close examination of the lignin : cellulose ratio shows, however, that there is a definite increase in this

ratio from nursery to outer wall. It has been pointed out by Mr. T. Greaves that constructional work on the termitarium is greater in the outer layers than in the inner, and that the termites work from inside. It appears then that the explanation of the higher lignin : cellulose ratio in the outer layers of the mound is that, during constructional work, portions of the mound are eaten and a further proportion of the undigested cellulose is digested and absorbed.

4. Acknowledgments.

I am indebted to Mr. C. S. Piper, of the Waite Institute, Adelaide, for the analyses on which the study of variation in composition has been made, and to Mr. W. E. Cohen, of the Division of Forest Products, Melbourne, for the determination of lignin and cellulose. It is also a pleasure to acknowledge my indebtedness to Mr. G. F. Hill whose wide knowledge of termites in general and of *Eutermes exitiosus* in particular has always been readily made available to me.

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An Analysis of Termite (*Eutermes exitiosus*) Mound Material.

*By W. E. Cohen, B.Sc.**

1. Introduction.

In the course of investigations that are being undertaken by the Division of Economic Entomology, and which have as their object the development of a standard laboratory termite colony, consideration is being given to the chemical composition of natural mound material. Preliminary examinations of some samples having indicated that the greater proportion of the material was of organic origin, the determination of cellulose, lignin, and other woody constituents was undertaken at the request of the Division of Economic Entomology.

2. Nature of Investigation.

Since the mound material was not entirely of organic origin, it was necessary to improvise methods of analysis. The application of these methods was not without difficulties, and hence the following brief description of the methods finally employed may be of interest.

Termite mound material consists of (i) organic substances, many of which may be recognized as degradation products of wood or other cellulosic materials, and (ii) inorganic substances apparently including clay, which is possibly the cementing material employed by the termites. The presence of this clay presents difficulties when attempts to determine cellulose, lignin, etc., are made. Such determinations involve a number of chemical operations, each of which introduces a filtering process at some stage or other. With such a substance as clay present, and with no possible means of altering its colloidal condition without affecting the organic constituents of the mound material, none of the usual filtering processes can be employed. Thus, such filtering media as alundum crucibles, fritted glass, Gooch crucibles, and filter paper soon become impervious. Furthermore, the latter cannot be used with safety when the determination involves its own substance, i.e., cellulose. The only alternative to filtering during this analysis was to centrifuge, and, therefore, throughout the methods that are described below, all operations involving the separation of solids from liquids were carried out by centrifuging.†

3. Methods of Analysis.

Cellulose was determined by means of a procedure which differed in detail only from that described by J. A. Daji for the determination of cellulose in soil(1), and any reservations which apply to the results obtained by using his method must necessarily apply to those recorded in this paper. The procedure employed was as follows:—

Duplicate samples were weighed out in each case, approximately 3 gms. of material being taken for each duplicate, and a moisture determination (by oven-drying at 105° C.) was made for each sample at the time of weighing out. The accurately weighed samples were

* An officer of the Division of Forest Products.

† NOTE.—It is of interest to mention that numerous delays, caused by the shattering of the glass centrifuge tubes at the high speed of the machine in use, were finally avoided by the introduction of a water cushion between the glass tubes and the metal centrifuge cups.

placed in beakers (250 cc.) and 0.5 per cent. sodium hydroxide solution (80 cc.) was added to each sample. The covered beaker and its contents were heated in a boiling water-bath for 30 minutes, after which they were allowed to cool and the solid material to settle. The supernatant liquor was decanted and centrifuged for 15 minutes before being discarded. All residual solid material was transferred to the beaker using 1 per cent. hydrochloric acid (80 cc.), after which the contents of the beaker were heated in a boiling water bath for 30 minutes and then allowed to cool and settle. The supernatant liquor was decanted with a siphon tube and centrifuged for 10 minutes. The residue in the beaker was washed four times with hot water (80 cc. each time). On each occasion, the contents of the beaker were separated by decantation and centrifuging. By this time, the solid residue was acid-free, and, after removing all excess water by centrifuging, the material was returned to the beaker using cold water (76 cc.) and 4 cc. of sodium hypochlorite (containing 15 per cent. available chlorine) was added. The mixture was allowed to stand in the cold, with occasional stirring, for 30 minutes. It was then centrifuged for 15 minutes and the supernatant liquor was discarded. This delignification process was repeated until the supernatant liquor was only the colour of sodium hypochlorite of the same strength. For outer and inner wall material, two, or at the most three, treatments sufficed. For the nursery material, five such treatments were necessary, indicating a greater lignin content. Each treatment was followed by centrifuging and the discarding of the supernatant liquor. Between each treatment one wash with cold water (40 cc.) was given to the material contained in the centrifuge tubes.

At this stage, Daji recommended the addition of dilute hydrogen peroxide, in small amounts at a time, until effervescence ceased, excess being avoided. In the present investigation, centrifuging and washing made it possible to remove all hypochlorite. At any rate, when hydrogen peroxide (20 cc. of 10 vol. H_2O_2 diluted to 100 cc.) was added in small amounts to the residue, no effervescence occurred. It was therefore considered that this part of the procedure could be safely omitted and some time saved.

The delignified residue was next given a cold water wash (80 cc.), and the wash liquor removed by centrifuging. Hot water washes (80 cc.) were then employed, the residue, on each occasion, being transferred to the beaker for the purpose. Finally, the wash liquors were found to be neutral, and, therefore, evaporation to dryness over a water bath could then be undertaken without harmful effects. For this purpose, the residue was transferred to an evaporating basin with the aid of water from a wash-bottle. The dried material was broken up as much as possible and carefully transferred to a measuring flask (100 cc.) using exactly 100 cc. of Schweizer's solution* during the process. The stoppered flask and its contents were then shaken in a rotary shaker for eight hours at the rate of 50 shakes a minute. The remaining solid material was then allowed to settle overnight. By means of a siphon tube, more than 50 cc. of the clear supernatant liquor was decanted into a stoppered Erlenmeyer flask. From the latter, using a pipette, exactly 50 cc. of the solution was added to 200 cc. of alcohol (80 per cent. by weight) contained in a beaker

* Of a number of methods that were tried, the most satisfactory procedure for the preparation of Schweizer's solution was that which has been described by many investigators and which involves the passing of air through strong ammonia in which copper turnings are suspended.

(400 cc.), and the precipitate thus formed was allowed to settle overnight. The supernatant liquid was then decanted through a weighed alundum crucible (R.A. 98) or a weighed Gooch crucible fitted with an acid-treated and previously ignited asbestos pad, the latter being the more suitable. After the upper liquid had all been filtered, 50 cc. of a mixture of alcohol and hydrochloric acid (40 cc. of 80 per cent. alcohol plus 10 cc. HCl.) were added to the precipitate in the beaker; the mixture was stirred till all the copper hydroxide was dissolved, and was then allowed to stand for about one hour. The upper liquid was then filtered through the same crucible, the precipitate washed free of copper with hot water, then transferred to the crucible, washed further with hot water, and then with alcohol and ether in turn. The crucible and its contents were dried in an oven at 105° C. for two hours, and then weighed, ignited for 30 minutes in a muffle furnace at 600° C., and again weighed. The loss in weight on ignition multiplied by two represented the amount of cellulose in the original sample of mound material.

Lignin was determined in mound material which had previously been extracted with 0.5 per cent. sodium hydroxide at the temperature of the boiling water bath for one hour and washed free from alkali. The purified residue was treated in the cold with 72 per cent. sulphuric acid(2), and subsequently with boiling 3 per cent. sulphuric acid in order to hydrolyse all carbohydrate material. The solid residue consisted of lignin and inorganic substances. After it had been washed free of acid, it was evaporated to dryness in a platinum dish, dried in the oven at 105° C., and weighed. The amount of lignin present was determined by igniting the oven-dried residue, and re-weighing, the loss in weight being estimated as lignin.

Total pentosans were determined by the procedure usually employed in wood analysis(3). It was found that 2 grams of the outer wall material and 1 gram of each of the inner wall and nursery materials were required in order to conform with the conditions of the method.

Solubility in 0.5 *per cent. sodium hydroxide* was determined by extraction of about 3 gms. of material with 100 cc. of the alkali solution for one hour at the temperature of a boiling water bath. After centrifuging, washing, neutralizing with dilute acetic acid solution, and further washing, the residual material was dried and weighed.

4. Results of Analysis.

The results of an analysis of the material from the outer wall, inner wall, and nursery of one termite (*Eutermes exitiosus*) mound are as follows (Table 1):—

Table 1.—Results of an Analysis of Outer Wall, Inner Wall, and Nursery Materials from One Mound, expressed as Percentages of the Oven-dry Weight of Original Material.

Location of Sample.	Total Combustible Matter.	Amount soluble in 0·5% NaOH.	Cellulose.	Lignin.	Ratio Lignin to Cellulose.	Total Pentosans.
Outer wall ..	48·3	36·9	2·4	11·5	4·8	4·7
Inner wall ..	79·9	43·6	5·6	23·8	4·3	8·0
Nursery ..	86·0	46·1	7·3	27·0	3·7	7·2

On account of the greater proportion of non-combustible material contained in the outer wall material, the results in Table 1 do not clearly reveal the fate of the ligno-cellulose substances which had originally been attacked by the termites. The following results (Table 2) have, therefore, been expressed on the basis of combustible material:—

TABLE 2.—SHOWING RESULTS OF ANALYSIS OF OUTER WALL, INNER WALL AND NURSERY MATERIALS FROM ONE MOUND, EXPRESSED AS PERCENTAGES OF OVEN-DRY COMBUSTIBLE MATERIAL.

Location of Samples.	Cellulose.	Lignin.	Total Pentosans.
Outer wall	5	24	10
Inner wall	7	30	10
Nursery	9	31	8

The results included in Table 2 might conveniently be contrasted with the values for hardwoods (eucalypt) and a softwood (spruce) which are indicated in Table 3—

TABLE 3.—RESULTS OF ANALYSIS OF HARDWOODS (EUCALYPTS) AND A SOFTWOOD (SPRUCE) EXPRESSED AS PERCENTAGES OF OVEN-DRY MATERIAL.

Type of Wood.	Cellulose.	Lignin.	Total Pentosans.
Hardwoods (eucalypts)	34 to 59	18 to 25	9 to 23
Softwood (spruce)	62	25	10

5. Conclusions.

It is apparent from the above figures (Tables 2 and 3) that the cellulose in the wood attacked by the termites is very considerably degraded as shown by the high percentage of material soluble in weak sodium hydroxide solution and the low percentage of cellulose in the organic matter. On the other hand, the percentage of lignin is of the same order of magnitude expected in wood substance, and therefore appears to have been little altered.

The extent of the change in the cellulose might indicate that the wood substance of the mound material has passed through the digestive tracts of the termites during which process only the cellulose constitutents have been altered.

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The Inheritance of Fluorescence in Hybrids between Perennial Rye-Grass and Wimmera Rye-grass.

By H. C. Trumble, M.Agr.Sc., and I. F. Phipps, M.Sc., Ph.D.†*

The article that follows has been furnished by the Director of the Waite Agricultural Research Institute (Professor A. E. V. Richardson), with an indication that it should be regarded as an integral part of the programme of investigational work on the mineral deficiencies of pastures in which the Institute, the Empire Marketing Board, and the Council are co-operating. An account of this work was given in a previous issue of this *Journal* (Vol. 5, No. 3, August, 1932, p. 141), and also in the Council's Pamphlet No. 17.—Ed.

Summary.

1. Wimmera rye-grass, when self-fertilized, produced both non-fluorescent and fluorescent seedlings, all of which, when grown to maturity, proved to be annual plants with variable but typical Wimmera rye-grass characteristics. Annual plants of Wimmera rye-grass, homozygous for non-fluorescence, have been isolated.

2. Hawke's Bay perennial rye-grass (*Lolium perenne*), when self-fertilized, produced non-fluorescent seedlings, all of which proved to be truly perennial.

3. The F_1 hybrids between Wimmera and Hawke's Bay rye-grass were perennial, but principally of the "short-lived perennial" type, and were either fluorescent or non-fluorescent, depending on whether a fluorescent or a non-fluorescent gamete from Wimmera rye-grass was effective in fertilization.

4. Fluorescence is inherited as a dominant character, dependent on one, and possibly two, genetic factors giving 3:1 and 9:7 ratios respectively.

5. The heterozygosity of Wimmera rye-grass for fluorescence and the non-fluorescent character of the annual rigid rye-grass (*L. rigidum*) indicate that the occurrence of fluorescence with annual or short-lived habit in Italian rye-grass (*L. multiflorum*), Wimmera rye-grass, and "false-perennial" rye-grass is merely a chance association.

6. Thus, in certain cases, when Wimmera rye-grass is growing in proximity to, or in association with, perennial rye-grass, the ultra-violet light test for perenniality may give a false estimate of the percentage of true perennial plants in the seed collected.

7. It is argued that the heterozygosity of Wimmera rye-grass for fluorescence lends support to the view that Wimmera rye-grass has originated from hybridism between Italian rye-grass (*L. multiflorum*) and rigid rye-grass (*L. rigidum*).

8. As Wimmera rye-grass is a segregating hybrid, it should not receive specific rank, and there is no justification for the botanical equivalents (*L. subulatum*, *L. rigidum* var. *strictum*, and *L. hybridum*) which have been applied.

1. Introduction.

Considerable interest has recently been aroused by the discovery of Gentner (4) that the roots of Italian rye-grass seedlings, when grown in contact with white filter-paper, produce a substance which exhibits fluorescence when exposed to filtered ultra-violet light. Linehan and Mercer (7), working with commercial rye-grasses, showed that Italian rye-grass (*Lolium multiflorum* Lam.) and the hybrid or "false perennial" types occurring in commercial samples exhibited the fluorescent

* Agronomist, Waite Agricultural Research Institute.
† Geneticist, Waite Agricultural Research Institute.

character, whereas true perennial rye-grass (*Lolium perenne* L.) was non-fluorescent. The practical importance of this differentiation lies in the means it affords of separating the seeds of perennial rye-grass from those of Italian rye-grass and inferior hybrid derivatives.

Foy (3), discussing the application of these results to New Zealand rye-grasses, states that all annual species of rye-grass exhibit complete fluorescence. This generalization is apparently based on the evidence of Linehan and Mercer (*loc. cit.*), who recorded it in Italian rye-grass, Western Wolths (*L. multiflorum* Lam. var. *Westernwoldicum*), darnel (*L. temulentum* L.), *L. remotum* Schrank., and *L. Brazilianum* Nees., and on Foy's own experience with Wimmera rye-grass.

In view of the increasing importance of both perennial rye-grass and the annual Wimmera rye-grass, in South Australia, the authors carried out hybridization experiments with selected plants of these two types during 1931. The object of this work was (i) to test the suggestion that annual and perennial habit were associated with fluorescence and non-fluorescence respectively, and (ii) to study the inheritance of the fluorescent character.

In the meanwhile, Corkhill (1) published a note on the inheritance of fluorescence in natural hybrids between *L. multiflorum* and *L. perenne* showing that these apparent hybrids, when self-fertilized, segregated in ratios approximating 3 fluorescent to 1 non-fluorescent. Still later, Linehan and Mercer (8), although they did not present data, published a note to the effect that fluorescence was inherited as a simple Mendelian dominant, and was not necessarily associated with the annual habit.

2. Material and Methods.

The parents employed consisted of typical Wimmera rye-grass plants selected from a commercial line, and perennial rye-grass plants selected from a certified Hawke's Bay (New Zealand) sample. The parent plants were collected from the experimental field and transplanted to pots, which were spaced at intervals within a large glass house.

Direct and reciprocal crosses were made by means of the emasculation and hand pollination method. In addition, several inflorescences of each parent were protected from cross-fertilization by bagging. Self-fertilized and reciprocally crossed seeds were not obtained in all cases, owing to pollen sterility and self-incompatibility in some parents.

The seeds obtained from the hybridization and self-fertilization of the parents were germinated on filter paper, and the filter papers subjected to the standard ultra-violet light test. The seedlings producing fluorescence were separated from the remainder in each set, and both fluorescent and non-fluorescent seedlings were transplanted to pots, and later planted out as single plants in the experimental field. As many F_1 hybrid plants as possible were self-fertilized, together with plants from each selfed parental line. The seeds obtained from these baggings were then subjected to the ultra-violet light test.

3. The Results of Selfing Wimmera Rye-grass and Hawke's Bay Rye-grass.

The parents employed were four Wimmera rye-grass plants (W.1, W.6, W.7, W.8), and six plants of perennial rye-grass (H.B.2, H.B.3, H.B.4, H.B.5, H.B.9, H.B.10). Each of these plants was self-fertilized by bagging, with the results shown in Table I.

Table I.—Percentage Fertile Seed Obtained from (*a*) Wimmera Rye-grass; (*b*) Hawke's Bay Rye-grass, when Self-fertilized.

Parent.	Percentage Fertile Seed.	Parent.	Percentage Fertile Seed.
W.1	4	H.B.2	†
W.6	Nil	H.B.3	13
W.7	46	H.B.4	Nil
W.8	Nil	H.B.5	3
		H.B.9	Nil
		H.B.10	Nil

† Seed formed, but percentage not recorded.

In both forms of rye-grass, the percentage of seed set as a result of self-fertilization was low. Sterility occurred in both H.B.9 and H.B.10, all the pollen of H.B.9, and 50 per cent. of the pollen of H.B.10 being abortive. On the other hand, W.6, W.8, and H.B.4 developed normal pollen, and produced fertile seeds when hybridized with other plants, indicating that in these three cases self-incompatibility was the reason for the apparent sterility.

Ten seedlings resulting from the self-fertilization of W.1 proved to be true annual* plants, with typical Wimmera rye-grass features, but 7 of these were fluorescent and 3 non-fluorescent at the seedling stage. The parent plant, therefore, was heterozygous for fluorescence, although homozygous for the annual character. Similarly, in the case of W.7, 8 fluorescent and 7 non-fluorescent seedlings were obtained, all of which proved to be typical annuals. In order to confirm the presence of the non-fluorescent character in the annual types, three of the annual plants were selected at random and self-fertilized in 1932. The seeds produced were tested for fluorescence, with the results given in Table II.

Table II.—Ultra-violet Light Test of Seedlings Resulting from Self-fertilized Non-fluorescent Annual Plants of Wimmera Rye-grass.

Pedigree No.	Parent.	Number of Seedlings.			Percentage Germination.
		Fluorescent.	Non-fluorescent.	Total.	
32–136–2 ..	W.1	2	8	10	46
32–136–3 ..	W.1	1	8	9	41
32–140–1 ..	W.7	Nil	62	62	72
	Total ..	3	78	81	..

* Plants which did not survive the first summer after planting have in all cases been designated "annuals," whereas all plants which were alive at the commencement of the second growing season have been termed "perennials."

Of the 81 seedlings examined, 78 were non-fluorescent and 3 fluorescent, thus confirming the designation of these three plants as non-fluorescent annuals. The three fluorescent seedlings probably resulted from accidental cross-pollination.

Twenty-one seedlings resulting from the self-fertilization of Hawke's Bay rye-grass parent plants were all non-fluorescent, and proved to be all perennials. Six of these plants were selfed during 1932, but only two produced fertile seeds. The seeds were tested for fluorescence, with the results shown in Table III.

TABLE III.—ULTRA-VIOLET LIGHT TEST OF SEEDLINGS RESULTING FROM SELF-FERTILIZED NON-FLUORESCENT PERENNIAL PLANTS OF HAWKE'S BAY RYE-GRASS.

Pedigree No.	Parent.	Number of Seedlings.			Percentage Germination.
		Fluorescent.	Non-fluorescent.	Total.	
32–133–1 ..	H.B.2	2	149	151	95
32–133–2 ..	H.B.2	2	148	150	86
	Total ..	4	297	301	..

Of the 301 seedlings tested, 4 were fluorescent and 297 non-fluorescent. The 4 fluorescent seedlings obtained are assumed to have resulted from accidental cross-pollination.

4. The Hawke's Bay x Wimmera Rye-grass Hybrids.

(i) *First Generation Plants.*

The classification of F1 plants into (*a*) fluorescent and non-fluorescent types, and (*b*) annuals and "perennials," is shown in Table IV.

TABLE IV.—CLASSIFICATION OF F1 PLANTS ACCORDING TO (*a*) SEEDLING ROOT CHARACTER; (*b*) LONGEVITY.

Hybrid.	Seedlings, Annual.	Fluorescent "Perennial."	Seedlings, Annual.	Non-fluorescent "Perennial."
H.B.2 x W.1 ..	..	..	..	1
H.B.5 x W.8 ..	3	2	..	..
W.8 x H.B.5 ..	..	3	..	..
W.1 x H.B.2 ..	..	8	..	7
W.7 x H.B.4 ..	..	1	..	..
W.6 x H.B.3 ..	..	4	..	..
Total ..	3	18	..	8

The 18 fluorescent "perennial" hybrids obtained were all true crosses, and indicate that the fluorescent seedling character is dominant, and the perennial character at least partially dominant. The incomplete dominance of the perennial character is indicated by the fact that the "perennial" hybrids, at the commencement of the second growing season, possessed fewer and less vigorous green shoots than the inbred Hawke's Bay rye-grass plants. These types in fact tend to resemble the "false perennial" types of Levy and Davies (6).

On the other hand, the 8 non-fluorescent "perennial" hybrids probably result from the union of a non-fluorescent annual gamete from Wimmera, with a non-fluorescent perennial gamete from Hawke's Bay rye-grass. This is obviously true in the W.1 x H.B.2 cross, in which W.1 was the female parent, and it was previously noted that both W.1 and W.7 were heterozygous for fluorescence (*vide* text p. 172).

The three fluorescent annuals from the cross H.B.5 x W.8 were noted as weak plants lacking in vigour, and may have died owing to poor vitality rather than as a result of an inherently annual character.

(ii) *Second Generation Plants.*

An attempt was made to obtain self-fertilized seeds from all the hybrid plants. Eight plants, however, failed to set seed, four plants produced less than 10 seeds each, and the germination of the seed produced in a number of cases was unsatisfactory. In determining the ratio of segregation into fluorescent and non-fluorescent seedlings, data have been utilized only from plants which produced more than 10 seedlings.

The F2 segregation of fluorescence and non-fluorescence falls into two groups, one in which the ratio is 3:1, and the other 9:7. The details of the F2 seedling counts from fluorescent "perennial" F1 hybrids, the segregation of which approximated to a 3:1 ratio, are shown in Table V.

TABLE V.—THE CLASSIFICATION OF FLUORESCENT AND NON-FLUORESCENT SEEDLINGS FROM F1 WIMMERA x HAWKE'S BAY RYE-GRASS HYBRIDS, SEGREGATING IN THE F2 GENERATION ON THE BASIS OF A RATIO APPROXIMATING 3 : 1.

Pedigree.	Parents.	Characters of F_1 Plant.*	F_2 Seedling Counts.			$\frac{D.}{P.E.}$	Percentage Germination.
			Fluorescent.	Non-fluorescent.	Total.		
32–134–6	W.1 x H.B.2	F.P.	24	10	34	<1	90
32–134–8	„	F.P.	8	3	11	<1	65
32–135–5	„	F.P.	14	4	18	<1	86
32–135–6	„	F.P.	9	4	13	<1	87
32–135–7	„	F.P.	7	4	11	1·3	69
32–135–8	„	F.P.	40	13	53	<1	70
32–142–5	W.7 x H.B.4	F.P.	529	182	711	<1	99
32–149–7	W.8 x H.B.5	F.P.	233	63	296	2·2	81
	Total observed ..		864	283	1,147	..	..
	Calculated 3 : 1 ..		860·25	286·75	1,147	1·2	..

* F = fluorescent. P = "perennial."

The above data indicate that in plants arising from the hybrids W.1 x H.B.2, W.7 x H.B.4, and W.8 x H.B.5, there is a segregation of fluorescent and non-fluorescent seedings in a ratio approximating 3 : 1.

In the F2 progeny of two F1 plants of the hybrid W.6 x H.B.3, there is an indication that the segregation is in the ratio of 9 fluorescent; 7 non-fluorescent, as shown in Table VI.

Table VI.—The Classification of Fluorescent and Non-fluorescent Seedlings from F1 Wimmera x Hawke's Bay Rye-grass Hybrids, Segregating in the F2 Generation on the Basis of a Ratio Approximating 9 : 7.

Pedigree.	Parents.	Characters of F Plant.	F_2 Seedling Counts.			D. P.E.	Percentage Germination.
			Fluorescent.	Non-fluorescent.	Total.		
32–143–5	W.6 x H.B.3	F.P.	51	33	84	1·2	67
32–143–7	„	F.P.	62	42	104	1·0	73
	Total observed ..		113	75	188	..	..
	Calculated 9 : 7 ..		105·75	82·25	188	1·6	..

The data shown in Table VI. give an excellent fit to a 9 : 7 ratio, suggesting that two factors are concerned in the production of fluorescence. Although F3 data is necessary to confirm this ratio, the fact that two plants from the same hybrid segregate similarly is fairly definite evidence.

The 8 non-fluorescent "perennial" plants present in the F1 group (*vide* Table IV.) were bagged, and 6 of these produced selfed seed. The details of the F2 seedling counts are given in Table VII.

Table VII.—The Classification of Fluorescent and Non-fluorescent F2 Seedlings from Non-fluorescent Perennial Plants in the F1 Group.

Pedigree.	Parents.	Characters of F_1 Plant.*	F_2 Seedling Counts.			Percentage Germination.
			Fluorescent.	Non-fluorescent.	Total.	
32–134–2 ..	W.1 x H.B.2	FP	2	52	54	83
32–134–3 ..	„	FP	0	18	18	82
32–134–4 ..	„	FP	3	11	14	42
32–135–2 ..	„	FP	0	62	62	83
32–135–3 ..	„	FP	5	69	74	87
32–135–4 ..	„	FP	3	79	82	85
	Total		13	291	304	..

* F = non-fluorescent. P = "perennial."

Two plants, 134-3 and 135-2, produced seedlings that were all non-fluorescent; in the remainder, a few fluorescent seedlings appeared in each case. It is assumed that the occurrence of the fluorescent seedlings was due to chance pollination by foreign pollen.

The absence of segregation from the non-fluorescent perennials in the F1 group confirms the classification shown in Table IV., and lends support to the explanation given, namely, that these have probably resulted from the union of a non-fluorescent annual gamete from heterozygous Wimmera rye-grass, with a non-fluorescent perennial gamete from Hawke's Bay rye-grass.

5. Views Concerning the Origin of Wimmera Rye-grass.

Wimmera rye-grass, as it is known in Southern Australia, is of comparatively recent origin. It was first recorded by Mullett (9) in 1919, but had apparently been known in the Wimmera district of Victoria for 32 years previously. As far as can be ascertained (9,10), the original material was imported from Europe by a Mr. McNichol, of Noradjuha, and the grass was known as Italian rye-grass for many years.

By 1919, this grass had demonstrated an undoubted agricultural value under the comparatively low rainfall conditions of the Wimmera wheat-growing areas. It was identified by Ewart as *Lolium subulatum*, Vis., and Hitchcock, in the United States, confirmed this designation. The name, however, was not accepted in New South Wales (10), where it has been classed as *Lolium rigidum* var. *strictum*, Jansen.

Recently, Morris in Ewart's *Flora of Victoria* (2), designates the grass as *Lolium hybridum* Hausskn (*L. perenne* x *L. multiflorum*) on the evidence that "apparently pure seed grown at Burnley, Rutherglen, Minyip, and in New South Wales yielded *L. perenne* and . . . . *L. multiflorum* . . . mixed with the Wimmera rye-grass type." Ewart adds a footnote, however, stating that "if the plant is a segregating hybrid the name *L. hybridum* is not justified." He also suggests that *Lolium rigidum* Gaud. may be native to Victoria, and that it may cross with *L. perenne*, yielding the forms mentioned above.

Seed samples of Wimmera rye-grass which have been tested at the Waite Institute from time to time have invariably yielded a mixture of diverse types, the majority of which range between typical *L. rigidum* and typical *L. multiflorum*, together with a small percentage of short-lived perennial forms. Jenkin (5), reporting on samples grown at Aberystwyth including the progeny of herbarium specimens, also found considerable variation, and concluded that the name "Wimmera" covers a mixture of types, and includes any rapid growing short lived rye-grass.

The majority of the types are strictly annual in character, stemmy in comparison with *L. multiflorum* or *L. perenne*, but leafier and more robust than *L. rigidum*, with a characteristic purplish colouration of the stem at maturity. The "seeds" are usually larger than those of any of the above three species, and may be either awned or awnless. The outer glume of each spikelet is usually well developed, and closely adnate to the rachis at maturity. The rachis is generally stouter than that of *L. multiflorum* or of *L. perenne*, and rather longer and relatively more slender than that of *L. rigidum*. In addition, there are frequently

present plants which closely resemble Italian rye-grass, others that are typically *L. rigidum,* and also occasional plants which are definitely perennial, and possess the botanical characteristics of perennial rye-grass.

Experience with Wimmera rye-grass over a period of eight years at the Waite Institute indicates that combinations of the characters present in *L. rigidum* and *L. multiflorum* are of frequent occurrence among the multiplicity of types evident. The more important agronomic and botanical characters such as inherent vigour, relative leaf and stem development, type of leaf shoot and texture of the leaves, rachis and spikelet features, and awn development are extremely variable, but for the most part tend to be intermediate between the above two species.

Moreover, the authors find that *L. rigidum* produces non-fluorescent seedlings as in the case of *L. perenne,* and this negatives Foy's statement that all annual species of rye-grass exhibit complete fluorescence. On the other hand, *L. multiflorum* is completely fluorescent. Wimmera rye-grass when self-fertilized yielded both non-fluorescent and fluorescent seedlings, all of which proved to be annuals (p. 172).

The extreme variability of Wimmera rye-grass in practically all agronomic and botanical features of importance, to which the occurrence of non-fluorescent and fluorescent types must now be added, indicates that Wimmera rye-grass is of comparatively recent origin, resulting from hybridism between the awned, leafy, fluorescent *L. multiflorum,* and the awnless, stemmy, non-fluorescent *L. rigidum,* followed by ecotypical selection. It is very probable that further hybridization between these derivatives and *L. perenne* has also occurred in certain cases. That samples of Wimmera rye-grass usually contain a high percentage of fluorescent seedlings is accounted for by the fact that fluorescence behaves as a dominant character, and that the grass is normally cross-fertilized.

Whether the heterozygosity for fluorescence in Wimmera rye-grass is widespread, or is merely a local characteristic, is not yet known. In general, intercrossing between Wimmera rye-grass heterozygous for fluorescence, and perennial rye-grass will tend to produce approximately 50 per cent. non-fluorescent hybrid seed.

In view of the evidence of segregation for major taxonomic characters in Wimmera rye-grass, it is obvious that no specific botanical name can justifiably be applied to this mixture of types.

6. Application of the Results to the Diagnosis of Rye-grass Types.

Recently, there has been a tendency to place much reliance on the ultra-violet light test as a positive means of differentiating true perennial rye-grass from Italian rye-grass and inferior hybrid derivatives.

Since the annual *L. rigidum* is non-fluorescent, however, and as Wimmera rye-grass when self-fertilized segregates fluorescent and non-fluorescent seedlings, all of which are annuals, it is evident that fluorescence and non-fluorescence are not necessarily associated with annual and perennial habit respectively. The occurrence of fluorescence in Italian rye-grass, Wimmera rye-grass, and "false perennial" types, as contrasted with the non-fluorescence of the annual *L. rigidum* and perennial rye-grass, is thus probably a chance association.

These facts, together with the now widespread distribution of Wimmera rye-grass, suggest that the ultra-violet light test may give a false estimate of the factors perenniality, type, productivity, &c., on which the value of rye-grass for permanent pasture depends. It is evident, therefore, that the test must be used with discrimination and caution, and that it cannot effectively replace the systems of inspection, sampling, and growing-on as single plants necessary in an efficient scheme of seed certification.

A final point of some interest is the almost invariable occurrence of a trace—usually 1 or 2 per cent.—of fluorescence in even the best and truest perennial rye-grass types. This is demonstrated by Foy's data (3), and has been shown by practically all samples examined at the Waite Institute. In three groups of selfed non-fluorescent plants (Tables II., III., and VII.), the authors unexpectedly obtained a similarly small percentage of fluorescent seedlings among the progeny. The occurrence of these fluorescent types has been tentatively attributed to chance cross pollination with fluorescent forms.

7. Presence of Fluorescence in Subterranean Clover.

During the course of the work, various pasture species have been subjected, whilst germinating on filter paper, to the ultra-violet light test. It has been found that whereas South Australian commercial subterranean clover is non-fluorescent, an early-flowering type from Dwalganup (Western Australia) which is becoming increasingly important in the lower rainfall areas is fluorescent. The fluorescence is, however, faint, and unlike rye-grass, the causal substance is confined to the root tissue, and not exuded.

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An Examination of the Amount of Iodine in the Thyroid Glands of Australian Merino Sheep.

By Mary C. Dawbarn, M.Sc., and F. C. Farr.†*

The thyroid gland manufactures an iodine-containing compound which is necessary for the normal growth and well-being of men and animals, and for the healthy growth of hair or wool. For this purpose, an adequate supply of iodine in the food is required. An insufficient intake of iodine resulting from deficient iodine in the soil leads to ill-health in both man and animals.

In certain districts of the United States of America, Canada, Switzerland, and New Zealand, goitre, an enlargement of the thyroid gland in the neck, has been very common among human beings and domestic animals from this cause. The effect on sheep has been serious, lambs being born with enlarged thyroids and hairless, and so weak that large numbers of them die.

When the Division of Animal Nutrition was founded in 1927, the late Professor Brailsford Robertson undertook a survey of the iodine available in Australian sheep pastures.‡ The direct determination of the amount of iodine in the soil or the pasture is troublesome and inaccurate, owing to the minute quantity present, but an animal feeding on a pasture accumulates the iodine for its own purposes, and the amount stored in its thyroid glands is a useful measure of the amount available. Consequently, the most satisfactory procedure to test whether the soil contains enough iodine is an analysis of the thyroid glands of the sheep themselves. If this iodine storehouse contains a sufficiency of iodine, there must be a sufficiency of iodine in the pasture. The work of American investigators, notably Marine, has shown that to ensure health the thyroid should contain at least 0.1 gm. of iodine per 100 gm. of dry gland, and that when iodine was abundant in the soil the amount might rise to 1 gm. or even more per 100 gm.

The results of our iodine survey have recently been published in the *Australian Journal of Experimental Biology and Medical Science*, **10**, p. 189, 1932, and some of the findings will be given here. Altogether, some 700 thyroid glands from sheep have been examined, and the dry weight and iodine content of each determined. Between 500 and 600 of the glands were obtained from "Meteor Downs," Springsure, Central Queensland; "Keytah," Moree, New South Wales; "Buln Gherin," Beaufort, Victoria; "Kolendo," Port Augusta, South Australia; and the south-eastern district of South Australia. The remaining glands were obtained from districts scattered about the Commonwealth, including Tasmania, but not Western Australia.

* Research Chemist to the Animal Products Research Foundation of the University of Adelaide.
† An officer of the Division of Animal Nutrition.
‡ For the reason that at this period many pastoralists have been so influenced by the dramatic results obtained by iodine feeding in other countries that they considered that if full benefit were to be obtained from their pastures, the stock grazing thereon should have access to an iodine-containing lick.

It has been found that there is considerable variation in the weight and percentage content of iodine of glands obtained from animals of the same sex, age, and locality, even when collected at the same time of year. To determine the influence of different factors on the thyroid, it has, therefore, been necessary to calculate the arithmetic mean of the results obtained from considerable numbers of glands in each of the groups to be compared. In this way, it has been possible to show that the sex and age of the sheep have very little, if any, influence on its thyroid iodine. The iodine content is affected more by the season of the year than by the locality from which the glands were collected. Drought has a marked influence on the iodine content. Five glands from "Mutooroo," South Australia, collected during drought, had iodine contents varying from 0.67 to 0.95 per cent.; the iodine content of six glands from "Mutooroo," collected in the good season following the drought, varied from 0.18 to 0.56 per cent. Similarly, the average content of iodine in the thyroids obtained from 38 wethers at "Kolendo," South Australia, during drought, was 0.719 per cent. The figure for twenty wethers obtained in the ensuing good season was 0.441 per cent.

Of all the glands examined, none showed a lower percentage of iodine on dry weight than 0.10, and the highest value obtained was 1.26. The average for all glands was approximately 0.5 per cent. No very enlarged glands were found. Thus there is no evidence of iodine deficiency in Australian sheep pastures as far as this survey extends.

At "Keytah," in northern New South Wales, an experiment has been carried out by the Division of Animal Nutrition to determine the effect of feeding sheep on licks containing potassium iodide. This experiment is described in another communication by E. W. L. Lines (see p. 181 *et seq.*). The amount of potassium iodide in the lick was changed periodically from 1 part in 1,000 to 1 part in 7,000, but the amount of iodine in the thyroids of the animals hardly varied over the whole period.

Moreover, the amount of iodine in the thyroids from the "Keytah" sheep was not appreciably different from that in the glands from the adjoining station of "Boonaldoon," where no iodine was given. This would seem to be additional proof that the natural pasture contained a sufficiency of iodine, and that feeding iodine-containing licks was unnecessary.

We would like to take this opportunity of thanking all the pastoralists who have sent us thyroid glands and information about sheep, pastures, and so on, particularly Messrs. R. G. Beggs, H. Boully, D. E. Donkin, E. D. Ogilvie, H. W. Seager, A. F. Sutton, and F. H. Tout.

An Experiment on the Effect of an Iodised Lick on the Growth and Wool of the Australian Merino Sheep.

*By E. W. L. Lines, B.Sc.**

(*With a note on soil types by R. G. Thomas, B.Sc.**)

1. Introduction.

Among the investigations projected when the Division of Animal Nutrition was formed was an inquiry into the effects of specific mineral deficiencies. The possibility that iodine deficiency in some districts would upset thyroid function sufficiently to restrict wool growth was considered, and the following programme of investigation was drawn up:—

(1) An examination of the thyroids of sheep collected throughout the year in several districts—(*a*) to establish a standard iodine content, and (*b*) to study seasonal variations under usual pastoral conditions.

(2) A determination of the effect of feeding iodine in districts where a shortage was suspected.

(3) The effect of partial and complete thyroidectomy on wool and body growth [Robertson (1929)].

This paper deals with the result of an experiment conducted under the second section of the programme. The results obtained under the first section have been published by Dawbarn and Farr (1932), and those of the third by Marston and Peirce (1932).

From examination of the thyroid glands collected in 1928 in the Moree district of New South Wales, Robertson opined that sheep in this area might have insufficient iodine in their diet. He therefore decided to test the influence of iodised licks on sheep depastured in this district.

In 1928, a field-station was established by the courtesy of E. D. Ogilvie, Esq., on his property, "Keytah," situated about 25 miles west of Moree, in latitude 29 deg. 30 min. S., longitude 149 deg. 30 min. E.

A note on the geology, soils, and topography is published by my colleague, Mr. R. G. Thomas, simultaneously with this paper.

Climate and Pasture at "Keytah."

The Moree district, in which this property is situated, has a mean rainfall of 21 inches. The district is about 230 miles from the coast, and lies between the regular orbits of the summer monsoonal rains and the regular winter rains of the southern part of Australia. "Coastal" rains are cut off by the New England mountains, some 5,000 feet high. In good years, the district receives both summer and winter rains, but in unfavorable years it may get neither, and the pastures fail completely unless natural irrigation from flooding of the Gwydir River occurs, following on heavy rains in the mountains to the eastward. As more than half the property is subject to this flooding several times a year, it is possible that the soil receives more moisture from this source

* An officer of the Division of Animal Nutrition.

in some years than it gets from local rainfall. These conditions probably have a marked effect on the botanical composition and nutritive value of the pasture. In Mr. Ogilvie's opinion, sheep do not do as well on country subject to flooding as the amount of herbage there would lead an experienced flock-master to expect.

The pasture plants which grow after rain or flooding vary according to the time of year. Summer growth is mainly grasses, *Panicum* spp. and *Calamagrostis* spp. are dominant; Mitchell grass (*Astrebla* sp.), Flinders grass (*Iseilma* sp.) and "white top" (*Danthonia* sp.) also occur. In winter, the prevailing plants are "burr clover" (*Medicago denticulata*), "crowsfoot" (*Geranium pilosum*), and geranium (*Erodium cygnorum*). Some of the perennial grasses, particularly *Danthonia*, shoot after autumn rains. A small water plant, *Marsilea Drummondii*, known as "nardoo," grows during, and after, floods, and is eaten freely by stock.

Paddocks.

The experimental area consisted of two very similar adjoining paddocks each about 300 acres in extent; both contained some "sand ridge" and "black soil" country, and were representative of the surrounding country (Fig. 1). A drafting yard and sheep scales were provided near the fence dividing the paddocks.

Management.

The lambs were weighed and ear-tagged within 24 hours of birth, and were weighed thereafter weekly to the nearest 0.2 kg.

The experimental and control lots in the second experiment were made up by dividing the ewe lambs alternately as dropped.

To equalize any difference in the fodder, the two flocks, together with their respective licks, were alternated between the paddocks every four weeks. Water was supplied either by a stream of artesian water from a bore some 2,000 feet deep, or by surface water left after flooding of the Gwydir River. The former water contains a fair amount of dissolved salts, and may have influenced the appetite for salt.

A considerable number of individuals were "struck" by the sheep blow-fly during the experiments, but there is no indication of any preference between the two lots of animals.

Weekly notes were made of the condition of the sheep and of the fodder as judged by the husbandman, and also any sickly or fly-struck animals were noted.

2. First Experiment.

In September, 1928, observations were commenced on the growth of 100 lambs of mixed sexes, which, together with their dams, had access to the station lick containing about 370 γ* of iodine per gm. During gestation, the station lick had contained about 740 γ of iodine per gm.

In April, 1929, a second group of 100 lambs were born whose mothers had not had access to iodised lick during gestation, and they were offered "iodine-free lick" from one month old.

Good to fair fodder conditions prevailed until June, 1929. From this time onward, drought caused a steady deterioration of the pastures, and by February, 1930, the natural pastures had completely failed, and the experiment was abandoned.

* γ = one-thousandth of a milligram.

Growth.

Although born seven months apart, the growth of the two groups was similar, as is shown by Table I.

Table I.—Growth of Lambs at "Keytah" in 1928 and in 1929. Body Weight off Pasture, in Kg.

Weeks of age	21	35	46
Iodised lick ♂ (males)	26.5 kg.	35.0 kg.	45·0 kg.
♀ (females)	24·5	31·5	40·0
Iodine-free lick ♂	26·5	35·0	..
(Controls) ♀	24·5	31·0	..

Fig. 1. Layout of experimental paddocks, "Keytah," 1928–31

The control lambs were somewhat lighter in weight than those getting iodised lick, until the curves crossed at 21 weeks old. At 35 weeks old the curves again crossed. After this age, the drought upset all comparisons.

This experiment was unsatisfactory because—

(*a*) the difference in birth date prevented the control being a true one, and

(*b*) the experiment was interrupted by drought.

3. Second Experiment.

During the middle of 1930, good rains were received, and another experiment was commenced.* Sufficient ewes to provide 220 ewe lambs were placed at the disposal of the Division from those mated to lamb in September, 1930. Prior to lambing, these animals had had access to a station lick containing about 100 γ of iodine per gm.

As is usual after a drought has broken, the fodder conditions were particularly good, and remained so until mid-November. From November onward, the pastures steadily deteriorated until further rains were received at the beginning of March, 1932, after which the fodder conditions were excellent. During June and July, 1931, flood waters confined the sheep to restricted areas, and the available fodder was indifferent in quantity and quality until the water receded.

Lick Intake.

On "Keytah" it is customary to give the sheep a salt "lick" containing iodine. In September, 1928, the station lick consisted of—

Salt	200 lb.
Bone meal	25 „
Superphosphate ..	25 „
Ground sulphur	6 „
Ferrous sulphate ..	4 „
Potassium iodide ..	2 oz. (= 374 γ of iodine per gm.).

This lick was used throughout as "iodised lick."

For "iodine-free lick," a mixture containing the same proportion of mineral salts was made up from Merck's G. R. and British Drug House's A. R. chemicals.

Lick consumption was ascertained each week from the difference between the weight of lick supplied and the amount left in the troughs, and dividing the consumption over the number of animals in the paddock, including lambs.

The iodine requirement of the sheep was not known, but, from Marine's experiments on school children in central United States of America, it was assumed that a daily dosage of 0.5 to 1 mg. of iodine would be sufficient. Enough potassium iodide was therefore put in the lick to ensure that this dose was present in the sheep's average intake of lick. Subsequently, Orr and Leitch (1929) published their computation of 400 to 2,000 γ of iodine as the ordinary intake of sheep on good Scotch pastures, which coincides with the estimate calculated from Marine's data.

It is impossible to foretell just how much lick an animal will eat. The appetite for licks containing phosphate and salt is affected by the state of maturity of the herbage, being much greater in the autumn than in spring. Richardson et al. (1931) have shown that the phosphate

* By H. R. Marston, Acting Chief of the Division of Animal Nutrition.

content of Australian natural pastures falls rapidly as the plant matures and sheds its seed. At other times, the appetite for salt is the controlling factor, and this may be influenced by the amount of dissolved salts in the drinking water available.

In the first experiment, during which the fodder conditions varied for the most part from "only fair" to very poor, the animals consumed both licks at the rate of 700 gm. per head per year. In the second experiment, when "good" to "excellent" fodder was available, little lick was eaten (Fig. 2), and the consumption was confined to two periods of poor fodder conditions. The intake over the time when lick was being eaten was at the rate of 520 gm. per head per year. The mean intake over the whole period of the second experiment, i.e., from birth to a mean age of 47 weeks, was—

Iodised lick—0.5 gm. per head per day containing 185 γ of iodine.
Iodine-free lick—0.6 gm. per head per day.

As the intake of lick did not differ significantly as to date or amount between the two lots, it seems that the iodine content had no effect on the appetite for lick.

Growth.

The growth of the experimental and control lambs in the second experiment is shown in Fig. 2, using the method of Robertson and Ray (1925) in which "the increase of weight with time is represented by an area of which the middle point at any given age is the ascertained average weight, and the width of the area is twice the 'probable error' of the average."

These animals did not grow quite as well as those of the first experiment. Attacks by the blow-fly were severe during the latter half of the year, and the lower average live weight is partly attributable to this cause.

In the graph, the rainfall, fodder conditions, and intake of lick over the duration of the experiment are shown.

By the end of the experiment, when their average age was 47 weeks, 96 and 92 lambs were surviving from the two lots of 100 new-born lambs put on "iodine-free" and "iodised" lick, respectively.

Wool.

The wool shorn from each animal was carefully sorted and weighed. The individual weights were obtained for "fleece," "pieces," and "bellies." The yield of each individual fleece was judged, after "skirting," and that of the bellies, pieces, and locks in bulk. The "locks" of each lot were weighed together. The figures so obtained were used to compute the production of clean scoured wool of each individual.

Mean Wool Production per Head—all ♀ Second Experiment.

—	Greasy.	Clean.	S.D. Clean.	S.E. of Mean.	Mean Age.
	Lb.	Lb.	Lb.	Lb.	Weeks.
Iodine-free lick	7·51	3·592	0·398	0·041	47
Iodised lick (No. 2) ..	7·56	3·595	0·367	0·040	47

Mean and Standard Deviation computed from individual variates.

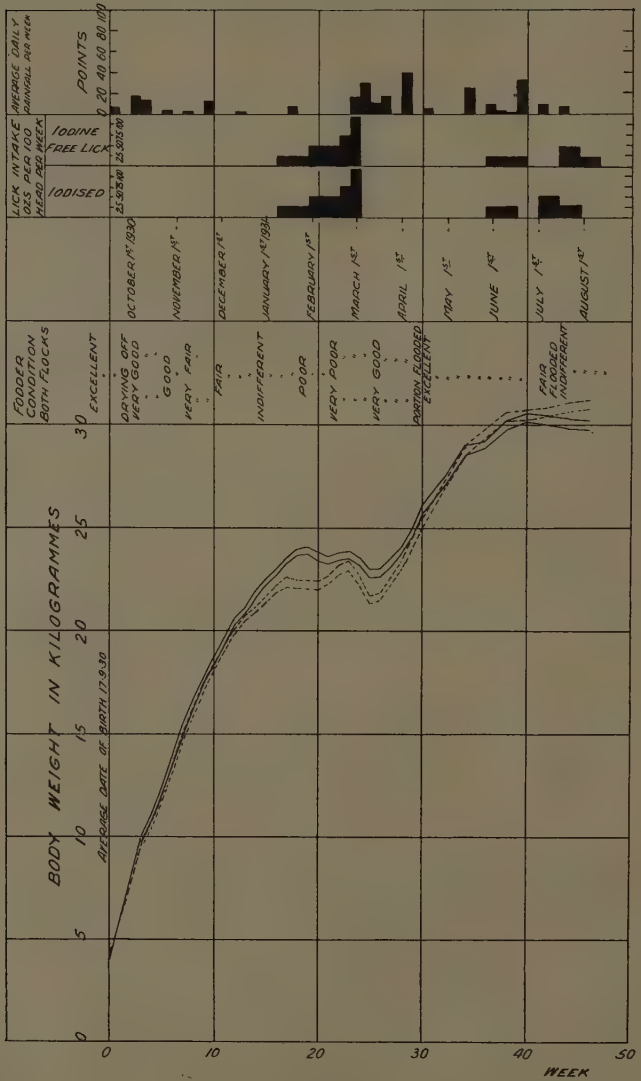

FIG. 2. Chart showing the growth, lick intake, &c., of the ewe lambs used in the experiment commenced in 1930. The weights of those receiving the iodised lick are indicated by the broken lines. The weights of the control group which received an iodine free lick are indicated by the unbroken line

Distribution of Variates. Pounds of Clean-scoured Wool.

Class mean ..	2·5	2·7	2·9	3·1	3·3	3·5	3·7	3·9	4·1	4·3	4·5	4·7	4·9	5·1
Iodine-free ..	1	2	5	14	7	14	28	12	5	4	3	0	1	0
Iodised lick ..	0	1	4	7	19	17	19	11	9	3	0	1	0	1

Distribution of Estimated Spinning Counts.

Spinning count	60's	60/64's	64's	64/70's	70's
Iodine-free	21	11	48	6	10
Iodised lick	9	16	51	11	1

The close agreement between the means of the body weights and of the wool clips is unusual, especially as the distributions of the variates tended to be "platykurtic."* The yearly culling of animals below a certain standard of production and the retention of the higher producers would tend to cause a distribution which was not "normal" in the statistical sense. This latter effect was not due to age at shearing, as the mean wool production of the younger half of each group did not differ significantly from that of the older.

4. Conclusions.

Increasing the intake of iodine by an average of 185 γ per day for 47 weeks had no significant effect on the growth or wool production of lambs at "Keytah," New South Wales. Owing to variations in the pasture during the second experiment, lick was eaten during nineteen weeks only, so that the average intake was much less than that in the first experiment, which was 720 γ iodine per day. However, as 185 γ per day is three times that calculated by v. Fellenberg (1926) to be the requirement of the growing child, the lambs should have responded definitely thereto were they suffering from any insufficiency of iodine.

This conclusion is supported by the result of analyses by Dawbarn and Farr (1932) of 171 glands collected from this district during the currency of these experiments. They found that the average iodine content of the thyroids of 101 sheep receiving iodised lick at "Keytah" (D_1 series) was 0.60 per cent., and that of 70 glands from "Boonaldoon," a similar adjoining property† (D_2 series), was 0.55 per cent. This difference is not significant—using the terminology of Fisher (1930)—t = 1.83, n = 168 and P lies between 0.10 and 0.05. The mean for some 500 Australian glands which they analysed was 0.56 per cent. iodine. It therefore appears that the iodised licks fed to the D_1 series of sheep at "Keytah" failed to alter the iodine content of their thyroids significantly.

* Here used according to K. Pearson, meaning that the variates tended to be distributed further from the mean than is normal.

† But where no lick was fed.

5. Acknowledgments.

The author's thanks are due to E. D. Ogilvie, Esq., and to Messrs. O. K. Samuel and V. Curtin, who made the field measurements; to Mr. G. W. Bussell, who prepared the graphs; and last, in point of time, to Sir Charles J. Martin for his help and criticism during the preparation of this paper.

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Appendix.

NOTES ON SOIL TYPES AT "KEYTAH."

By R. Grenfell Thomas, B.Sc.

The soils at "Keytah" form two main groups, the "sand-ridge" soils and the "black soil" of the plains. The vegetation of these two types is quite distinct, and the junction between them sharp and well defined. The black-soil plains are usually quite devoid of timber, but support an abundant growth of grasses, whereas the sand ridges are often quite heavily timbered. In many instances, there appears to be a definite zoning of timber on the sand ridges. The central and higher portions may support a tree association comprising sandalwood, wilga, &c., to belah, pine, and beefwood. The outer edges of the sand ridges near the black soil usually show a well-defined zone of box gum, while at the actual junction of the water-course country with the sand ridges, coolibah trees are almost invariably present.

The central sand-ridge soils often show a bare clay-pan surface devoid of grass and timber. The subsoils of the sand ridges are generally hard brown clay, carrying nodules of gypsum and calcium carbonate.

The black-soil plains show little change in character down to 27 inches below the surface.

The main features may be summarized as follows:—

(1) The whole area has reached a condition bordering on base level as regards drainage.

(2) The soils are almost exclusively transported alluvials derived from the highlands to the east. They range from early Post Tertiary to Recent.

(3) The early alluvium consists largely of gravels and sands; the more recent alluvium is mostly made up of clays and fine silts, indicating a constant falling off in the transporting power of the western drainage system.

A Preliminary Survey of the Distribution of the Hookworm of Sheep in New South Wales.

By G. Kauzal, D.V.Sc., and N. P. H. Graham, B.V.Sc.†*

Up to the last few months of the year 1932, Mr. Graham was an investigator located at the F. D. McMaster Animal Health Research Laboratory under the Australian Pastoral Research Trust—Empire Marketing Board scheme (see this *Journal*, Vol. 4, August, 1931, page 1933). At the request of the Trust, however, he was then transferred to the Trust, so that he is now a full-time officer of that body. His headquarters still remain at the McMaster Laboratory, but from time to time the Trust uses him to investigate particular problems that have been referred to it by its members. In between times Mr. Graham also assists with his former investigations. The work described in the article that follows was carried out in between periods of visits to individual stations made at the request of the Trust.—Ed.

1. Introduction.

The first record of the occurrence of the hookworm of sheep, *Monodontus trigonocephalus*, in Australia was made by Gordon (1932) in sheep examined at the Homebush Abattoirs. In view of the pathogenic importance of this species in other countries, it was considered desirable to determine, with as much accuracy as possible, its distribution in New South Wales. A survey was carried out by the routine examination of sheep by one of us (G. K.) at the Metropolitan Meat Industry Board's Abattoirs, Homebush Bay, and the Sydney Meat Preserving Company's Works, Auburn, while examination of sheep in the field and at local slaughter yards was also carried out by one of us (N. P. G.).

As a result of the abattoir examination, 39 cases of infestation with *M. trigonocephalus* have been found, out of a total of 456 sheep examined at the abattoirs, giving a percentage of 8.6. In general, it was found that the individual infestations were light, but invariably accompanied by marked macroscopic lesions, mainly in the form of haemorrhage into the mucous membrane of the small intestine. While the average degree of infestation was 21.9 worms per sheep, in a few instances up to 100 worms were present.

As a result of the local examination of sheep on individual properties and at small country slaughter houses, eighteen further cases of infestation were found out of a total of 58 sheep examined. In the majority of these, infestation was extremely light, and in some of them only a single worm was found.

2. Distribution of the Parasite.

As a result of the routine examination of sheep at Sydney Abattoirs, the hookworm was found to occur in sheep from five Pastures Protection Districts, namely, Merriwa, Singleton, Upper Hunter, Tamworth, and Armidale. Local examinations confirmed the finding of the parasite

* An officer of the Council's Division of Animal Health.
† Veterinary Officer, Australian Pastoral Research Trust.

in the first four of the above districts, and also revealed its presence in the Glen Innes Pastures Protection District. In infestations found in this district, however, only a single worm was present in each of two sheep.

It has been found, where the actual properties from which the infested sheep came could be determined, that all of these, with one exception, lay on the eastern side of the Great Dividing Range. In one district in particular, this was rather strikingly brought out, since on three properties lying to the west of the Dividing Range no cases of infestation were found, whereas on each property visited on the eastern side infestation occurred.

Though from the results of this survey it is indicated that *Monodontus trigonocephalus* is already well established and of common occurrence, since out of a total of 514 sheep examined from all sources, 57—i.e., 11.1 per cent.—were found infested, it is not considered that this gives any real indication of the incidence throughout the State as a whole. So far as local examinations in the field were concerned, these were expressly concentrated on those districts in which the parasite had already been found to occur, while even at the Sydney Abattoirs there was a preponderance of sheep examined from the northern and central divisions of the State. So far as the survey has gone at the present time, the heaviest infestations and the greatest percentage of cases have come from the Upper Hunter and Singleton Pastures Protection Districts. A survey is at present being carried out by one of us (N. P. G.) embracing the southern part of the Central Tablelands and Southern Tablelands and slopes, in order to determine if possible whether the parasite is present in that part of the State. So far, there has been no evidence that it does occur to the south of the districts already found infested.

In conclusion, it may be mentioned that in other parts of the world the hookworm of sheep has been found to have a very wide distribution, and is by no means confined to warm and temperate zones. Cameron (1932) has pointed out that it is not uncommon in sheep and deer in the cold highlands of Scotland. If it can be determined that the parasite at the present time has a relatively limited distribution in Australia, it should be possible to concentrate on eliminating the present source of infestation before further expansion of its distribution occurs.

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Parasitological Field Trials With Sheep.

Results at "Frodsley," Tasmania, and "Meteor Downs," Queensland.

The work, the results of which are given in the article that follows, forms part of the programme of investigations that is being undertaken by the Council's Division of Animal Health under the Australian Pastoral Research Trust—Empire Marketing Board scheme (see this *Journal*, Vol. 4, August, 1931, p. 133). The two trials reported on were carried out with the kind co-operation of Mr. K. Brodribb, of "Frodsley," Tasmania, and Major D. Donkin, of "Meteor Downs," Queensland, who have, at all times, greatly facilitated the experiments by supplying the use of the necessary land and experimental sheep.—ED.

I. Experiments at "Frodsley," Tasmania.

By I. Clunies Ross, D.V.Sc., and N. P. H. Graham, B.V.Sc.†*

Summary.

1. Routine monthly treatment with carbon tetrachloride and copper sulphate led to no increase in wool or body weight in sheep mainly infested with small Trichostrongylid worms. It is known that these parasites are resistant to any known treatment.

2. There was, however, a marked improvement in wool quality in treated compared with untreated sheep, so that it is probable that treatment mitigates somewhat the adverse effects caused by these parasites.

3. Sheep on improved pasture, either with or without treatment, showed marked increase in body weight, and produced over 2 lb. more wool per head than the sheep on natural pasture, either treated or untreated. The only difference noted between treated and untreated groups on improved pasture was a slight improvement in wool quality in the treated sheep.

4. The wool of sheep run on improved pasture was estimated to give as high, or higher, percentage clean-scoured yield as that of any sheep on natural pasture.

5. The administration of sodium arsenite and copper sulphate in licks had no demonstrable effect in diminishing infestation with the large bowel parasites, *Chabertia ovina* and *Oesophagostomum venulosum*.

1. Introduction.

In 1931, the Council for Scientific and Industrial Research conducted a field trial on "Frodsley," in Tasmania, to determine the effects of various methods of medicinal treatment in controlling losses in sheep, supposedly due to helminth parasites. The results of that trial (see this *Journal* **5** : 31, 1932) indicated that, although parasitic infestation was principally due to small Trichostrongylids (*Ostertagia* spp., *Trichostrongylus* spp., and *Nematodirus* spp.), and large bowel parasites (*Oesophagostomum venulosum* and *Chabertia ovina*) all of which are known to be difficult to control, regular treatment with either carbon tetrachloride or copper sulphate not only lessened mortality, but led to some increase in wool and mutton production. Such increase, however, was not sufficient to produce either a satisfactory wool yield or mutton carcass.

* Officer-in-Charge of the Council's F. D. McMaster Animal Health Laboratory.
† Veterinary Officer of the Australian Pastoral Research Trust.

During 1932, a further trial was conducted, in order to confirm the findings of 1931, and, in addition, to see whether by means of pasture improvement, both with and without treatment, a satisfactory standard of wool and mutton production might be reached. It was also desired to experiment further with the use of a phosphatic lick against large bowel parasites. This lick also contained copper sulphate and sodium arsenite, and was one which Veglia (1928), in discussing the control of *Oesophagostomum columbianum*, had suggested as being of value. Finally, the value of oats as a supplementary feed for sheep, both with and without meat meal, was investigated, in view of the widespread use of the former as a sheep feed in Australia.

2. Details of Trial.

During the present trial, 210 cross-bred ewe lambs were employed, these being weaned at the commencement of the trial, at which time they were four to five months old. The lambs were each ear-tagged, and then were divided into seven groups, each of 30 lambs. Each group, except Nos. 6 and 7, was supplied with a basal phosphatic lick containing bone flour 45 parts, dicalcic phosphate 45 parts, and salt 10 parts.

Groups 1, 2, 3, 4, and 5 were run on natural pasture, at the rate of approximately 1 sheep to 1½ acres. From month to month, each group was moved in rotation through five paddocks.

Groups 6 and 7 were run separately on improved pastures at the rate of 1½ sheep to the acre, the paddocks being alternated each month.

The several lots were treated individually, as follows:—

Group 1.—Drenched at monthly intervals with 2 cc. carbon tetrachloride in 3 cc. liquid paraffin.

Group 2.—Drenched as in Lot 1, receiving also an addition to the basal phosphatic lick of sodium arsenite 1 part, copper sulphate 4 parts per 1,000 of the lick.

Group 3.—Drenched as in Lots 1 and 2, but also receiving a supplement of ¼ to ½ lb. of oats per day from March to the end of October, the average consumption throughout being 6 oz. per head per day.

Group 4.—Drenched at monthly intervals with 50 cc. of a 1 per cent. solution of copper sulphate.

Group 5.—No medicinal treatment.

Group 6.—Medicinal treatment as in the case of Group 1.

Group 7.—No medicinal treatment.

In addition to the above seven groups, a group of a further 40 lambs, some of which were the culls of the mob, were run on unimproved pasture, under pasture conditions not strictly comparable with those of Lots 1 to 5. These were not drenched, but were given supplementary feeding with meat meal and oats, of which the quantity consumed will be detailed later, and the same medicinal supplements in the lick as in the case of Group 2. This lot may be designated *Group* 8, though no strict comparison can be made between it and the other groups.

At the beginning of the trial, the mean body weights of the several groups were as follows:—

Group 1.—49.8036 ± 0.8977 lbs.
Group 2.—50.6000 ± 0.7862 lbs.
Group 3.—50.5333 ± 0.7849 lbs.
Group 4.—49.2167 ± 0.8065 lbs.
Group 5.—50.8333 ± 0.8835 lbs.
Group 6.—48.8667 ± 0.7853 lbs.
Group 7.—51.7333 ± 0.6898 lbs.
Group 8.—48.1842 ± 0.6083 lbs.

Unfortunately, the statistical treatment of these group weights was not possible before the commencement of the trial, since Dr. Carr Fraser, in examining them subsequently for homogeneity, has found that Groups 6 and 7 were not statistically homogeneous, though each is homogeneous with all other groups. Group 8 has also been found by Dr. Fraser to be non-homogeneous with Group 7.

Climatic and Other Conditions during the Trial.—No rain was recorded in January after the first weighing and drenching of the several lots. In February, the rainfall was not recorded, but conditions continued to be very dry throughout this month, pastures drying off markedly in all lots, and being well eaten down in the improved pasture lots (Nos. 6 and 7). During the following ten months, the rainfall was as follows:—

March	4.21	inches.
April	2.25	„
May	0.72	„
June	3.60	„
July	2.50	„
August	4.25	„
September	6.00	„
October	3.35	„
November	1.00	„
December	1.51	„
Total	35.30	„

Owing to the topdressing with superphosphate of the paddocks of Groups 6 and 7 being delayed until March, no shoot of clovers and other herbage followed the March rains, and, owing to this and the depredations of rabbits, both lots lost markedly in weight, Group 6 suffering particularly. So serious was this, that from the 8th April to the 8th May, it was necessary to move both lots to another improved pasture paddock. From April onwards, however, there was a satisfactory response from these pastures, as is reflected by the steady gains in weight made by Groups 6 and 7 on being returned to them on 8th May, and onwards through the severe winter months. The year, as a whole, was considered a very favourable one for the district, and all lots did very much better than the corresponding groups in 1931.

Parasitic Infestation.—The type and degree of parasitic infestation in all groups was followed each month by culturing faeces taken from three sheep in each group selected at random when the sheep were mustered for weighing and drenching.

At the beginning of the trial, post-mortem examination showed the predominant infestation to be with small Trichostrongyles, mainly *Ostertagia circumcincta* and *Trichostrongylus* spp. (*T. instabilis, T. rugatus,* and *T. vitrinus*) while *Nematodirus* spp. were also numerous. The degree of infestation with *Nematodirus* sp. was rather difficult to compare with that of the other species, owing to developmental peculiarities of the larvae, and also the very poor egg-laying properties of this species. The larvae of large bowel parasites, considered to be chiefly *Oesophagostomum venulosum,* comprised a relatively large percentage of larvae in cultures (0 to 25 per cent.), while some *Chabertia ovina* were also present.

Haemonchus contortus, which some years previously was said to have been an important parasite on this property, was found, as in 1931, to be present to only a very slight degree, whether in treated or untreated lots. *Cooperia* spp. also comprised a very low percentage of larvae in the several lots.

The degree of infestation as shown by faecal culture did not appear to suffer any marked variation, but this method of determining such variation was frequently unsatisfactory, owing to the faeces being very soft and even diarrhoeic, particularly following the heavy rains in August and September.

3. Results Obtained.

Though certain sheep died in each of Groups 2, 3, 4, 5, and 6, it was only possible to carry out detailed post-mortem examinations of two of these, No. S 177 from Group 6, and S 76 from Group 3.

S 177 (Group 6) died on 23rd July, and the viscera were kindly examined by Mr. D. T. Oxer, B.V.Sc., of the Tasmanian Department of Agriculture, and all parasites were collected. Infestation with parasites was found to be very light, the species present being *Ostertagia circumcincta, Trichostrongylus* spp., and *Nematodirus filicollis.*

S 76 (Group 3) was seen to be losing condition rapidly during July, and in August was forwarded by Mr. Brodribb to Mr. Oxer for examination. The animal was destroyed by Mr. Oxer, the worms in the stomach were counted, and those in the small intestine forwarded to this Laboratory. After counting several samples totalling over 1,000 worms in suspension, it was estimated that there were approximately 30,000 present in the stomach and small intestine, of which approximately equal numbers were *Trichostrongylus* spp. and *Nematodirus* spp. At the same time as this sheep was seen to be losing condition markedly, S 117 (Group 4) was also found to be similarly affected, and at the September weighing it had lost 11 lb. weight since June. It was sent to Mr. Oxer in Launceston, but recovered on receiving artificial feeding. Probably, this sheep would have been found to be as heavily infested as S 76.

At the September weighing, it was found that in each of Lots 1 to 5, a number of sheep had lost over 6 lb. weight. The very heavy infestation of S 76 and sheep treated monthly with carbon tetrachloride illustrates the relative inefficiency of this treatment to control small Trichostrongyles.

Mortality.

During the twelve months of the trial, the mortality in the various groups was as follows:—

Group 1	0
Group 2	2
Group 3	2
Group 4	1
Group 5	3
Group 6	1
Group 7	0

As has been mentioned, autopsies were performed only on S 177 and S 76. In the first of these, the cause of death could not be determined, but it did not appear to be due to parasitism, infestation being extremely light. In the case of S 76, death could certainly be considered to be due to parasitism (H. McL. Gordon, in unpublished work, has found an infestation with 9,000 to 10,000 *Trichostrongylus instabilis* sufficient to cause death in lambs three to four months old, running with their mothers, and receiving hand-feeding in addition). Though the higher mortality is in no way significant, it is of interest to note that more animals died in the untreated control group than in any other—a similar result to that noticed in the 1931 trial, when the control group suffered by far the heaviest mortality.

Consumption of Lick.

It is to be remembered that Groups 1, 3, 4, and 5 received a basal phosphatic lick, comprising dicalcic phosphate 45 per cent., bone flour 45 per cent., and salt 10 per cent. Consumption per lamb per day was negligible from January to March, but from April to October, consumption varied markedly from group to group. From October onwards, consumption of lick in these lots again became negligible, except in Lot 3, in which it averaged 6.2 gms. per day. The average daily consumption per sheep from April to October was as follows:—

Group 1, 2 gms. Maximum in any month, 3.45 gms.
Group 3, 11.6 gms. Maximum in any month, 17.3 gms.
Group 4, 2.4 gms. Maximum in any month, 3.45 gms.
Group 5, 1.9 gms. Maximum in any month, 2.9 gms.

It is seen that Group 3, which received an average daily supplement of 6 oz. of oats per head per day from April to November, consumed very much more of the lick than any of the other basal lick groups.

The consumptions of lick per head per day by Groups 2 and 8, which received the same basal lick as the other groups, but with the addition of medicinal supplement in the form of sodium arsenite 1 part, and copper sulphate 4 parts per 1,000, were as follows:—

Group 2, 0.8 gms. Maximum in any month, 1.9 gms.
Group 8, 8.1 gms. Maximum in any month, 12.8 gms.

Here again, as in the case of Group 3, it appears that the feeding of an oat and meat supplement to Group 8 resulted in greatly increased consumption of minerals. This very much higher consumption of lick by both lots receiving supplementary feeding in the form of concentrates is of considerable interest.

The abnormally low consumption of lick by Group 2 is thought to be due to the very bitter nature of the drugs added. Groups 6 and 7 on improved pasture received no licks.

Consumption of Food Supplements.

Group 3, which received a daily ration of oats varying from $\frac{1}{8}$ lb. to $\frac{3}{4}$ lb. per head per day from April to November, consumed in all 80 lb. per head. The 40 sheep in Group 8, which received the meat and oats supplement, consumed 120 lb. of oats per head, over the same period, and 19 lb. of meat meal from June to November.

Body Weights.

The accompanying graphs* illustrate that all four lots on natural pasture without supplementary feeding exhibited a negative growth curve until the spring shoot occurred, as seen at the October weighing. The loss of weight tended to be most severe in the case of the control Group 5. In the case of Group 3, receiving the oats supplement, some slight gain occurred during the negative phase of the other groups; this also occurred in the case of Group 8, receiving the oats and meat meal supplement. At the time of shearing on 23rd November, the gains in weight per head in the several groups, exclusive of the fleece weights, were as follows:—

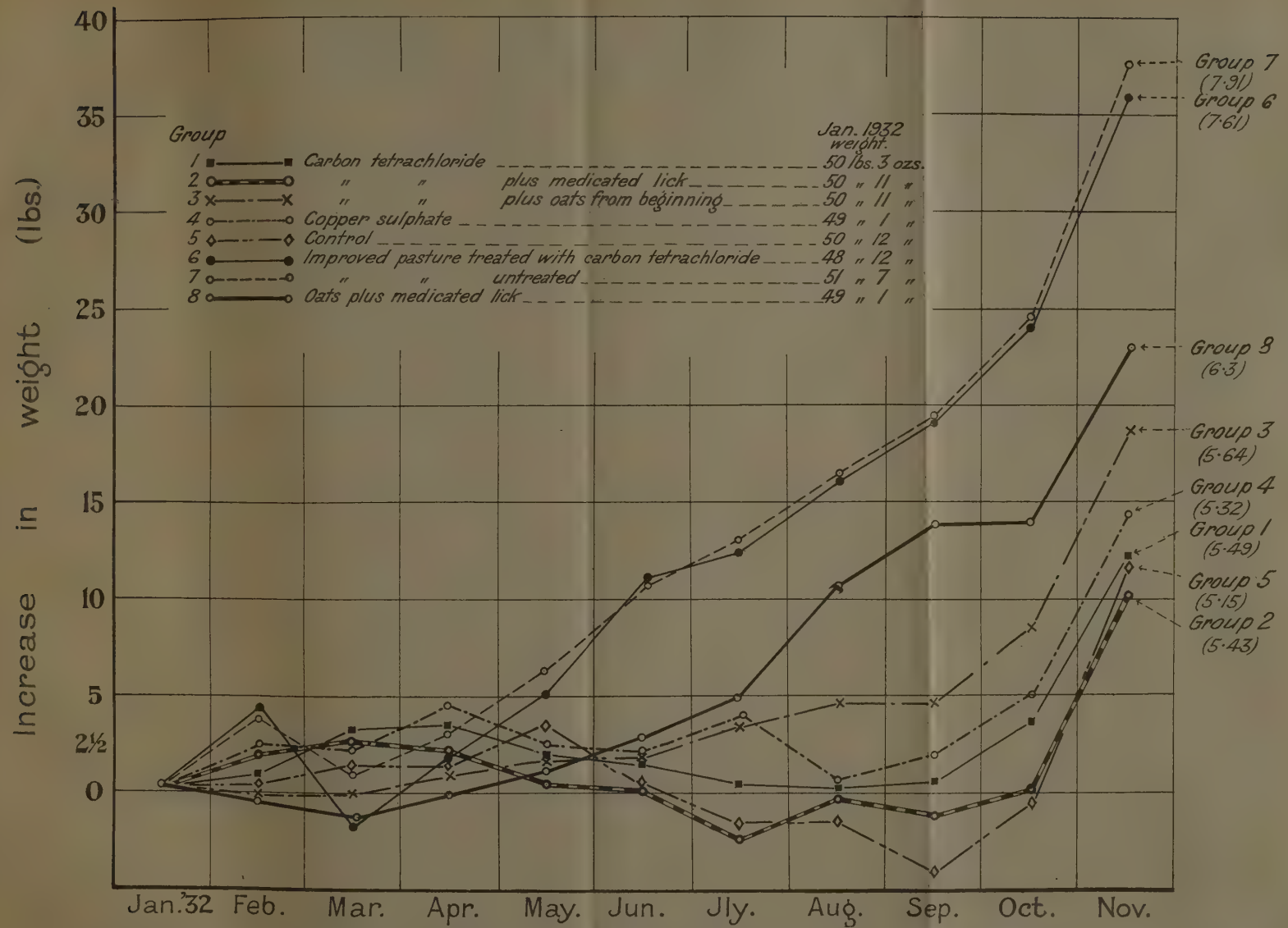
Group 1	6.8 lb.
Group 2	5.7 lb.
Group 3	15.0 lb.
Group 4	7.6 lb.
Group 5	8.2 lb.
Group 6	31.9 lb.
Group 7	33.3 lb.
Group 8	21.0 lb

The final weighing of all groups was made on 14th and 15th January, 1933, after completing twelve months of the trial. The final weights per head and the gains since the beginning of the trial were as follows:—

Group 1—	Average weight,	65.25 lb.	Gain,	16 lb.
Group 2—	„	„	67.0 lb.	„	16.4 lb.
Group 3—	„	„	79.18 lb.	„	28.65 lb.
Group 4—	„	„	69.7 lb.	„	20.49 lb.
Group 5—	„	„	69.33 lb.	„	18.5 lb.
Group 6—	„	„	93.57 lb.	„	44.7 lb.
Group 7—	„	„	98.95 lb.	„	47.2 lb.
Group 8—	„	„	79.31 lb.	„	31.12 lb.

Dr. Carr Fraser has found that the differences between Groups 1, 2, 4, and 5 are not significant, and it appears, therefore, that medicinal treatment on natural pasture resulted in no gain in body weight when compared with the untreated control Group 5. This lack of indication of any beneficial effect from medicinal treatment as far as body weight is concerned is probably due in part to the fact

* Based on monthly weighings, those in November being taken before shearing.



Graphs showing gains in weight of groups of experimental sheep at "Frodsley," Tasmania, during 1932. Each group was given a different treatment against internal parasites. The figures in brackets under the group numbers on the right denote average wool weights per head.

that the helminth species present were mainly *Ostertagia* spp. *Trichostrongylus* spp., *Nematodirus* spp., *Chabertia ovina* and *Oesophagostomum venulosum*, against none of which has any satisfactory treatment been devised. In contrast, Groups 3 and 8, on natural pasture with supplements, showed definite increases in the weight gained, but these, in view of the high consumption of expensive supplements, are relatively slight. The difference between these two groups, in spite of the fact that one received a meat meal supplement and consumed more oats, is not significant.

In the case of Groups 6 and 7, on improved pasture, at a rate of stocking double that of the natural pasture groups, both groups showed very much greater gains than any natural pasture groups, but again there is no significant difference between treated and untreated, and the untreated group actually made a greater average weight gain. As has been mentioned, owing to lack of homogeneity at the beginning of the trial, there is no logical basis for comparison of these groups, although each is comparable with Groups 1, 2, 3, 4, and 5.

Wool Weights.

All groups were shorn on 23rd November. Each individual fleece was weighed and classed for general quality, count, length of staple, and estimated clean-scoured yield. The average wool production in each group was as follows:—

Group 1	5.49 lb.
Group 2	5.43 lb.
Group 3	5.64 lb.
Group 4	5.32 lb.
Group 5	5.15 lb.
Group 6	7.61 lb.
Group 7	7.91 lb.
Group 8	6.3 lb.

The differences shown in wool weight between Groups 1, 2, 3, 4, and 5 are not significant. As in the case of body weight, medicinal treatment, even combined as in the case of Group 3 with supplementary feeding with oats, resulted in no significant increase in wool production.

Group 8, which received meat meal in addition to oats, cut slightly more wool than the natural pasture groups, but from an economic stand-point the increase was unimportant in relation to the high cost of the supplements fed.

The two improved pasture groups showed a very marked increase over any of the natural pasture groups, the difference between the treated and untreated lots not being significant, but again the untreated lot produced a slightly higher average yield.

Quality of Fleece.

In contrast to the lack of any significant difference in the amount of wool produced in the treated and untreated lots, a marked difference was shown in the quality of the wool of the treated when compared with the untreated natural pasture groups. All groups on natural pasture and not receiving supplements showed a proportion of tender

wools, but this varied in the several groups, and was very much higher in the case of the untreated controls. The percentage in each group was as follows:—

Group 1	.. ..	6 per cent.
Group 2	.. ..	10.7 per cent.
Group 4	.. ..	17.9 per cent.
Group 5	.. ..	58.3 per cent.

No tender fleeces occurred in Group 3, which received the oats supplement in addition to medicinal treatment, but 9 per cent. occurred in Group 8. None of the sheep in Groups 6 and 7 showed any tender fleeces. In spite of this, according to the classer's estimate, the wool of Group 6 was considered to be definitely superior in quality to that of Group 7, it being estimated that it was of at least 5 per cent. higher value.

The apparent influence of treatment in improving wool quality by decreasing the number of tender fleeces indicates that quality of wool may be a more sensitive indicator of adverse conditions than the weight of fleece produced, just as in the previous trial (Clunies Ross and Graham, 1932) there were indications that under improved pasture conditions fleece weight was a more sensitive indicator of the effects of internal parasitism than body weight.

Effect of Improved Pasture on Fleeces.

(i) *Count.*—The fleeces in each group were classified into the following classes:—56 to 56-58, 58 to 58-60, and 60 to 64. It was found that the improved pasture groups showed a definite, though relatively slight, lowering in count when compared with the natural pasture groups, whether treated or untreated, or whether receiving supplements.

In all natural pasture groups, the largest class of fleeces fell within the 60 to 64 group. In the case of Groups 6 and 7 (improved pasture) on the other hand, the largest group of fleeces fell in the 58 to 58–60 class.

Groups 3 and 8, receiving supplements, produced as high a percentage of 60 to 64 fleeces as natural pasture groups without supplements.

It is again necessary to stress the fact that the commonly held idea that a relatively slight lowering of count, such as occurred on improved pasture in the present trial, and in that previously reported (Clunies Ross and Graham, *loc. cit.*) is not necessarily any indication of lowering in value of the fleece. It is known that a well and evenly-grown 58's wool may have as high a spinning value as a poorly grown 64's, and in this connexion the proportion of tender fleeces in all natural pasture groups without supplementary feeding is contrasted with the 100 per cent. of sound fleece in the improved pasture groups.

(ii) *Estimated clean-scoured yield.*—The estimated clean-scoured yield is based solely on an expert classer's estimate, and while this estimate may not be exact so far as the actual yield is concerned, there is no reason to doubt that it does give an accurate indication of the relative yields of the several groups. As in the trial quoted above, it was again found, contrary to commonly held views, that the improved

pasture groups gave as high a percentage of high-yielding fleece (66 to 68 per cent.) as any of the other groups. In fact, in the case of Group 6, there was a higher percentage than in any other group.

In this connexion, it might be mentioned also that the work of Marston (1932) also shows that supplementary feeding, even when leading to very marked increase in wool production, does not lead necessarily to a lessening of clean-scoured yield.

Parasitism at the End of the Trial.

At the end of the trial in January, a number of sheep in each group (except Group 1) were examined post-mortem, to determine the degree and type of parasitism present. Though this examination was designed to determine any gross variation in the degree of infestation in the several groups, it had the special object of determining whether the medicinal supplements added to the licks in Groups 3 and 8 had any effect in reducing the numbers of large bowel parasites (*Chabertia ovina* and *Oesophagostomum venulosum*) in these groups. So far as the general parasitism was concerned, it was found to be extraordinarily light in all groups. Apparently, the heavy infestations suffered by some sheep in the late winter and spring (e.g., S 76) had been very largely thrown off, even by untreated sheep, as a result of improved nutrition.

Infestation with *Haemonchus contortus* was extremely light, not more than three worms being found in any sheep in any group, even in the control untreated Group 5. *Ostertagia* and *Trichostrongylus* sp. were present in the majority of sheep, whether treated or untreated, but there was no significant difference in the numbers present in any group, with the possible exception of Group 7, in which two sheep were entirely negative. *Nematodirus* was absent in all sheep, with the exception of one animal in Group 2 in which only a very few individuals were present.

In the case of the large bowel parasites, comparison was first made between the sheep in Group 8, in which the consumption of lick containing medicinal supplements had been high, and in the control untreated group. In this group, of which six animals were killed, the average number of *Chabertia ovina* was 3.66, and of *Oesophagostomum venulosum* 24.33. In Group 5, of which five animals were killed, the average number of *Chabertia ovina* present was 7.0, and of *Oesophagostomum venulosum* 24.2. There is no significant difference, therefore, in the number of large bowel parasites present in the untreated control group, and the group receiving and consuming large amounts of medicated supplements in the form of a lick. There is no evidence, therefore, that such supplements had any effect on the large bowel parasites.

It might be noted, however, that the other natural pasture groups examined, Groups 2, 3, and 4, had a considerably larger average number of these parasites than the control untreated group on natural pasture. In the case of Group 2, which also received medicinal supplements, but of which the average consumption was extremely low, the average number of *Chabertia ovina* was 1, and of *Oesophagostomum venulosum* 42.

Only two sheep were found entirely free both from *Chabertia ovina* and from *Oesophagostomum venulosum*, these being in Group 7.

4. Discussion.

The present experiment offers some confirmation of that of 1931, in that, though 1932 seasonal conditions were much less severe, so that there was no differential mortality rate nor differences in production of wool or mutton, definite beneficial effects of medicinal treatment against small Trichostrongyles were made evident by the much better wool quality of the treated sheep on natural pasture, compared with the control group (Group 5). At the time of shearing in November, in the opinion of the wool-classer, which was confirmed by Mr. D. T. Oxer, B.V.Sc., Group 5 was quite obviously the most unattractive of all groups in general appearance, and this was borne out by the analysis of the fleeces showing the much greater number of tender fleeces in this group.

In spite, therefore, of the known inefficiency of treatment with either carbon tetrachloride or copper sulphate against the small Trichostrongyles of sheep, it is evident that such treatment may serve to mitigate their effects. It does not make less necessary the development of more satisfactory methods of treatment and control than are at present available.

The improved pasture lots, Groups 6 and 7, indicate that not only is very great improvement in wool and mutton production possible by improved pastures, but that with adequate nutrition the effects of parasitic infestation, under the conditions obtaining in the present trial, become apparently negligible, as gauged by wool and mutton production in treated and untreated groups. Compared with the best average wool production of any natural pasture group without supplements (Group 1), namely, 5.49 lb., both improved pasture groups produced more than 2 lb. per head more, and, at twice the stocking per acre, 9 lb. more per acre. In addition, compared to the best gain in body weight on natural pasture without supplement, they produced over 20 lb. more in liveweight per head, or over 115 lb. more per acre. In addition, a survey of paddocks 6 and 7 at the beginning of the summer showed that they could have carried an extra lamb per acre.

The use of medicinal supplements in licks in the group (Group 8) in which consumption averaged over 8 gms. per head per day throughout the trial was not found to lead to any decrease in the number of *C. ovina* or *Oc. venulosum* present, when compared with the untreated control (Group 5). Consumption of medicinal supplements in the groups would be equivalent to approximately 240 mg. (4 grains) of sodium arsenite per month, and 960 mg. (16 grains) of copper sulphate per month, or double the dose of these drugs usually used in combination in routine treatment of sheep. The supplements are even less likely to prove effective under Australian field conditions, in that, when used, lick consumption appears to be decreased owing to the bitter nature of the drugs. Thus, in Group 2, which did not receive any food supplement, the average consumption was only 0.8 gms. per day. The high consumption in Group 8 appeared to be associated with the feeding of food supplements.

The results in the present trial do not bear out the indications of the 1931 trial that these drugs administered in the lick had lessened infestation with the large bowel parasites, but confirm experimental

evidence (Clunies Ross, 1932) of the futility of endeavouring to control parasitic infestation by adding medicinal supplements to licks and drinking water.

So far as the food supplements are concerned, the use of oats at the rate of 6 oz. per head per day from April to November (seven months), costing approximately 5s. per head, led to a disappointing increase in body weight, and no significant increase in fleece weight. However uneconomic such continuous feeding might be, it was to be expected that at least some increase in wool production might have resulted. It is true that all fleeces in this lot were sound, whereas 58 per cent. of fleeces in Group 5 (control untreated) were unsound. This, however, was the only definite value of the supplement so far as wool production was concerned. In this connexion, it must be remembered that oats are very commonly fed as a supplement to sheep in Australia, in Western Australia up to 1 lb. per head per day being given for months at a time in certain districts. It would appear very doubtful whether feeding on such a scale is justifiable, and whether equally good results might not be obtained much more economically such as by other supplements, improvement of pastures, &c.

Group 8, which received an average of 9 oz. oats per head per day from April to November, and 1.9 oz. of meat meal from June to November, at a total cost of approximately 9s. 3d. per head, showed no significantly greater increase in weight than Group 3, but produced a significantly greater amount of wool (6.3 lb. per head, compared with 5.6 lb. in Group 3). Again, the gain in body and wool weights was entirely insignificant in relation to the cost of the supplements fed.

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2. Experiments at "Meteor Downs" during 1932.

By I. Clunies Ross, D.V.Sc., and N. P. H. Graham, B.V.Sc.

Summary.

1. Treatment with carbon tetrachloride under the conditions obtaining through this trial led to no increase in body weight in the treated animals as compared with the untreated animals.

2. Treatment with carbon tetrachloride led to no increase in fleece weight, nor significant difference in wool quantity.

3. It is thought that the very low rainfall contributed largely to the lack of evidence of harm caused by parasites.

1. Introduction.

The field trial on "Meteor Downs" was devised to supplement that carried out in 1931, which, unfortunately, had to be abandoned owing to drought conditions, after having been in operation for only a few months. The objects of the trial were:—

1. To determine the effect on worm infestation and on wool and mutton production of drenching at monthly intervals with carbon tetrachloride.

2. To determine whether, when administered in conjunction with monthly drenching with carbon tetrachloride, the addition of sodium arsenite and copper sulphate to the basal phosphatic lick supplied to all groups would effect some satisfactory measure of control of *Oesophagostomum columbianum* (the nodule worm) in the large bowel, which is known to be resistant to ordinary anthelmintic medication.

3. Whether the addition of sodium arsenite and copper sulphate to the lick, without carbon tetrachloride drenching, would effect any reduction in the number of *Haemonchus contortus* (the stomach worm) as well as *Oesophagostomum columbianum*.

The experimental sheep comprised four trial lots:—

Lot 1 receiving carbon tetrachloride at monthly intervals, and a basal phosphatic lick;

Lot 2 receiving carbon tetrachloride at monthly intervals, with addition of sodium arsenite and copper sulphate to the basal phosphatic lick;

Lot 3 receiving medicinal lick only, with no drenching; and

Lot 4 being the control, and receiving the basal phosphatic lick only.

2. Conditions during Trial.

All the sheep were rotated in turn through four experimental paddocks, which had been left unstocked since the previous August. Stocking was light, only 30 sheep being run on 80 acres. Pasture conditions were very good at the beginning of the trial, and individual lots made gains up to 9 lb. per head in a single month. Rainfall throughout the trial was very low, and the total for the year comprised only 11.91 inches, which is very much below the average for the property. It is thought that this low rainfall was responsible for the fact that parasitic infestation was light throughout.

Body Weights.

Lot No.	Average weight at beginning of trial.	Average weight at end of trial.	Gain.
	(lb.)	(lb.)	(lb.)
1	42·6	91·0	48·4
2	36·2	92·0	55·8
3	40·8	88·0	47·2
4	40·8	92·6	51·8

Unfortunately, at the beginning of the trial, Lot 2 was non-homogeneous with the other groups, but it might be noted that it gained the most of all lots. The only other significant difference is between Lot 4 and Lot 3, the former being the control lot, and the latter receiving medicated lick only. So far as the body weights are concerned, therefore, all that can be said is that treatment certainly resulted in no gain.

Wool Weights.

All sheep were shorn at the end of the trial, in January, 1933, the average weights of wool per head for the several lots being:—

Lot 1	..	..	.. 9.24 lb.
Lot 2	..	..	.. 8.49 lb.
Lot 3	..	..	.. 8.53 lb.
Lot 4	..	..	.. 8.98 lb.

The difference between Lot 1 and Lots 2 and 3 is almost significant, but that between 1 and 4 is not. It is seen that one lot receiving carbon tetrachloride drenching cut slightly more wool than the others, while the other carbon tetrachloride lot, receiving also medicated lick, cut the least of all lots. According to the classer's estimate, the fleece in Lots 1 and 2 were of slightly better quality than those in 3 and 4, but the individual analyses of the fleece do not indicate this definitely.

Lick Consumption.

Lick consumption throughout the trial was light, and the highest was 5 gms. per sheep per day; the lowest during one or two months was a little more than 0.75 gm. per sheep per day. Consumption in Lots 2 and 3 (medicated) was not appreciably lighter.

Parasitic Infestation.

At the beginning of the trial, parasitic infestation was heavy, in four lambs of the same age killed before the trial the average degree of infestation being over 1000 *Haemonchus contortus*. Apparently, through being placed on clean paddocks which had been spelled for five months, and through the good condition of the pastures, the lambs received a good start, and at no time did the untreated lambs suffer in comparison with the treated.

So far as the efficiency of drenching is concerned, it was found in months in which no rain fell that the monthly treatment with carbon tetrachloride almost completely eliminated infestation with *H. contortus*. This was seen particularly at the January weighing, no rain having fallen for over a month.

At the end of the trial, five sheep from each group were examined post-mortem. In Lots 1 and 2, out of 10 sheep examined, only two showed any *Haemonchus* infestation, and then with only a few worms in a single sheep from each group. In Lots 3 and 4, 9 out of 10 sheep examined showed light to moderate degrees of infestation, the number of worms being estimated as from 50 to 500.

During the months in which several falls of rain occurred, it was found that even the treated groups showed a high percentage of *Haemonchus* larvae at the next monthly weighing.

So far as the *Oesophagostomum* infestation was concerned, against which the medicinal supplements were employed, infestation in all groups was light, and there was no significant difference in the numbers found in any group. This confirmed the findings in the Tasmanian trial.

3. Conclusion.

As a result of the evidence obtained in this experiment at "Meteor Downs," namely, that light to moderate degrees of infestation with *H. contortus* caused no interference with growth or wool production, a trial has been started on "Hinchinbrook" (see page 214) to investigate this point more thoroughly. The practical applications are possibly of importance, for should it be confirmed that sheep can tolerate a light to moderate infestation with worms—hitherto considered to be of some importance, depending on the degree of infestation carried—without reduction of growth or wool production, it would mean that drenching could be concentrated on eliminating heavy degrees of infestation, and safeguarding against these when climatic conditions predispose to them.

Pyrethrum.

*By A. McTaggart, Ph.D.**

Evidence has recently been forthcoming that a few people in Australia are already producing pyrethrum, and that others would appreciate further information in regard to it. The article that follows may therefore be of fairly wide interest. If, however, it succeeds in drawing attention to the limited Australian market for pyrethrum it will have served one of the purposes of its publication. It can hardly be too strongly emphasized that by the planting of a few hundred acres the total Australian demand could be satisfied, and that extra plantings would mean that the very keen competition of the export trade would be encountered.—Ed.

1. Introduction.

In recent years, attention has been given in various countries to a study of cultural and other problems associated with pyrethrum (*Chrysanthemum cinerariaefolium*), the flowers of which, when dried and ground to a powder, form a raw material for the manufacture of one of the most effective and conveniently used insecticides, viz., the well-known fly spray. (Such sprays are made by leaching the powder from dried pyrethrum flowers with a petroleum oil fraction resembling kerosene, and adding small amounts of essential oils to scent the mixture.)

An incentive for such studies has, no doubt, been the phenomenal increase in the world production of pyrethrum, particularly in Japan. Recently, brief mention of the matter has been made in the press throughout Australia, and hence the following more detailed information may be of interest.

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* Senior Research Officer, Division of Plant Industry.

2. Brief History of Culture.

Pyrethrum is believed to have originated in the Mediterranean region. It appears to have been known in Persia for its insecticidal properties for several centuries. The early 19th century saw its introduction, or re-introduction, into Europe, from Persia. Then, as now, it was the red-flowered common species (*Chrysanthemum roseum* or *C. coccineum*) that was grown in that country. During the period 1850-60, a new and more valuable species (*C. cinerariaefolium*) was produced in Dalmatia. It was white or yellow-flowered, and was destined to become the most widely cultivated type of the present day.

In 1881, Japan introduced the plant from Dalmatia. Following successful experiments near Tokyo, serious cultivation began in that country in 1886. Cultivation spread rapidly, and the year 1896 saw its introduction into Hokkaido (the northern island of Japan), where 64 per cent. of that country's production occurs to-day. Japan now claims 70 per cent. of the world's yield of flowers. Austria and Jugo-Slavia also produce pyrethrum in fairly large quantities. In addition France, Switzerland, Spain, North Africa and Argentina grow the plant on a limited scale for home use.

Production in Japan.—The Great War having opened the world's markets for the product to Japan, cultivation of the plant in Hokkaido, in consequence, reached significant proportions. In 1914, less than 10,000 lb. per annum were produced there, with only 2,150,000 lb. in the whole of Japan. Owing largely to the conversion of land to the cultivation of pyrethrum (the only crop which at the time gave a profitable return for farm labour) phenomenal expansion of the pyrethrum acreage in Hokkaido took place. In 1926, the peak year, nearly 26,000 acres of the crop were grown on that island, which acreage yielded over 10,000,000 lb. of dried flowers. In Japan as a whole that year some 33,728 acres produced 15,993,037 lb. This proved to be over-production, and there has since been a decrease in the area cultivated.

The approximate average annual output per acre during the period 1911 to 1928 for Japan was 500 lb., while for Hokkaido province it was 347 lb. The apparently low average yield of the latter was due largely to the fact that on that island pyrethrum is grown in very poor soils—unfit for the cultivation of other crops. Moreover, irrigation is not practised there.

Cost of production and net income in Japan.

The average cost of production of pyrethrum and the net income per acre, in Japan, are as follows:—*

Total cost of production per acre over 5 years ..	=	£35	0	0
Average cost of production per acre per annum	=	7	0	0
Gross income per acre over 5 years (on basis of a crop during 3rd, 4th, and 5th years, totalling 1518.3 lb. at approximately 11¾d. per lb., the average price for the few years prior to 1930)	=	74	0	0
Net income per acre for the 5 year period ..	=	39	0	0
Net income per acre per annum	=	7	16	0

(Par value, 24.58d. per yen, was used in calculating.)

* From an article in the *Bull. Imp. Inst.* **28**: 328, 1930

Production in Europe.—On account of its superior quality, the Dalmatian pyrethrum product has of late years resulted in an increasing demand in Great Britain, France, Italy, Germany, and the United States of America. The year 1926 proved to be a year of over-production in Europe as it was in Japan. This resulted in a subsequent reduction of acreage, with a corresponding increase in price.

3. Experiments in various Countries.

In Great Britain, co-operative experiments conducted by the Plant Pathological Laboratory of the British Ministry of Agriculture and the Insecticides and Fungicides Department of the Rothamsted Experiment Station demonstrated that pyrethrum can be grown and harvested successfully in England, that the average yield of dried flowers was of the same order as that obtained elsewhere, and that the insecticidal efficiency of the product was not less than that of imported samples. Indeed, English-grown flowers in many instances showed a higher percentage of pyrethrins* than imported flowers. Fryer, Tattersfield, and Gimingham at Rothamsted showed that the toxicities of extracts of equal weights of pyrethrum flowers at different stages of development do not differ significantly. Tattersfield later showed that the percentage of pyrethrins present in the flowers increases up to the stage at which they are fully open, which finding was also arrived at by Gnadinger and Corl in America by use of a different analytical method. The practical importance of this discovery was such that with maturity came not only an increased yield of flowers but also an appreciably greater quantity of pyrethrins per unit area. It was also demonstrated at Rothamsted that a very poor sandy soil could produce an excellent sample of flowers, and that fertilizer applications did not markedly affect the yield and toxic quality of such. Tattersfield, Hobson, and Gimingham found 0.6 to 1.2 per cent. of total pyrethrins in the flowers, made up of approximately equal quantities of Pyrethrin I. and Pyrethrin II. (determined by the acid method). Tested in alcoholic solution against *Aphis rumicis* Linne, Pyrethrin I. was found to be 10 times as toxic to these insects as Pyrethrin II.

United States of America.—According to a report on pyrethrum trade conditions published by the Japanese Commercial Museum in San Francisco, in 1926, the United States of America is unsuited to the cultivation of the plant at competitive prices. That report showed that the republic is dependent upon Japan for at least 80 per cent. of her stocks of dried flowers, and that in 1926 she imported 8,061,000 lb. from that country. According to Glassford, flowers from all sources imported into United States of America increased from 3,000,000 lb. in 1923 to 9,000,000 lb. in 1929.

McDonnell, Abbott, Davidson, Keenan, and Nelson of the Bureau of Plant Industry, United States of America Department of Agriculture, showed that neither the commercial grade nor the locality where grown can be accepted as giving an accurate criterion of the effectiveness of the pyrethrum product against insects. They concluded that samples of the same grade may differ in efficiency more so than samples of different commercial grades, such differences arising from (i) variations in active constituents due to differences in variety, climate and soil; and (ii) variations in conditions associated with harvesting, and with methods of curing, shipping, and storing of flowers.

* The toxic principles of the pyrethrum flower (see under "Switzerland," p. 207).

The experiments of Gnadinger and Corl, referred to above, showed that pyrethrum flowers which have fully opened contain 18 to 61 per cent. more pyrethrin than the closed flowers, which for many years were thought, erroneously, to be superior. These workers also found 0.4 to 1.21 per cent. total pyrethrins in the samples of flowers and powders tested.

Glassford, writing on the economics of pyrethrum, referred to recent investigations having shown that, by use of proper materials to activate the pyrethrum powder, a spray of remarkably increased toxicity is obtained, the cost of spraying being as a result correspondingly reduced. This advantage, together with that associated with the possibility of doubling the yield of pyrethrins by allowing the crop to mature more fully before harvesting, might well result in the production of a finished pyrethrum spray reduced in cost by half the current price per gallon, thereby making it comparable in cost with lead arsenate spray. He also referred to experiments with pyrethrum dusts, pointing out that extract of pyrethrum when carried on the surface of dust particles is definitely increased in efficiency, the cost of dusting being thereby correspondingly reduced. Used in this way, the pyrethrins were efficient for some purposes at a dilution of 1 to 133,000.

According to the same writer, the average consular invoice values in the United States of America decreased from 47 cents (1s. 11½d.) a lb. in 1923 to 18 cents (9d.) a lb. in 1929. (Recent wholesale prices for dried pyrethrum flowers in the United States of America have been quoted as low as 16 cents (8d.) per lb.)

Switzerland.—Two Swiss chemists, Staudinger and Ruzicka, first isolated, determined the chemical structure of, and named, two toxic constituents in pyrethrum flowers—Pyrethrin I. and Pyrethrin II. They found them present to the extent of only from 0.2 per cent. to 0.3 per cent., and consisting of approximately 40 per cent. of Pyrethrin I. and 60 per cent. of Pyrethrin II. Staudinger and Harder later stated that the content of total pyrethrins may in favorable cases amount to 0.6 per cent. They also found no difference between open, half-open, and closed flowers in percentage of toxic constituents. (Later work by Tattersfield and by Gnadinger and Corl, above referred to, showed that the percentage of total pyrethrins increases with the maturity of the flowers.) A method for the chemical assay of pyrethrum preliminary to the development by selection and propagation of a strain of *Chrysanthemum cinerariaefolium* of higher toxic value than that now grown was also developed by these Swiss scientists.

Other Countries.—Pyrethrum was grown successfully in Kenya, and the dried flowers were tested in England. The report showed that the flowers contained a satisfactory content of Pyrethrin I., the analyses revealing 0.56 per cent., 0.28 per cent., and 0.39 per cent. for "full bloom," "half closed" and "buds" samples, respectively. The first and last samples were considered higher in Pyrethrin I. content than Dalmatian flowers of average quality, and all three samples to be worth a little less than the current (April, 1930) price of "open flowers" from Dalmatia (a fraction over 10d. per lb.).

Pyrethrum flowers of good quality have been grown in the Island of Cyprus, while tests carried out in Uganda, Tanganyika, and Trinidad showed that the pyrethrum plant grows there, but that it will not

produce flowers. At high elevations in tropical countries, however, flowers may be produced, as was shown by the tests conducted in Kenya.

4. Experiments in Australia.

According to Baron von Mueller, *Chrysanthemum cinerariaefolium* was grown on a large scale on the Lower Latrobe River, Victoria, some time prior to 1895. The powder produced from the flowers was described as being "very powerful."

Chrysanthemum roseum (Persian species) has lately been grown commercially at Milperra, New South Wales, and sprays are being made in Sydney from the flowers grown there.

At Ormond, Victoria, both *Chrysanthemum cinerariaefolium* and *C. roseum* have been grown on a commercial scale for the past three years.

In 1931, the Plant Introduction Section of the Division of Plant Industry, incidentally to its main work of introducing and testing varieties of grasses likely to be of value in Australia, introduced a small amount of seed of four strains of *Chrysanthemum cinerariaefolium*:—

C.P.I. No.	Strain.	From—
2273	Swiss	Viticultural Station, Lausanne, Switzerland, received through C. T. Gimingham, Brit. Ministry of Agric., Harpenden, Eng.
2274	Japanese Commercial ..	Japan, received through C. T. Gimingham, Harpenden, Eng.
2288	Japanese	Yokohama Nursery Co., Ltd., Yokohama, Japan
2289	Japanese	Japan, through Office of Drugs and Related Plants, U.S. Dept. of Agric., Washington

Seedlings were raised in flats (seed boxes) and transplanted into the field in October, 1931, at Black Mountain, Canberra. The plants were set out in rows 18 inches apart and 12 inches apart within the row. They were periodically watered during the dry period of the year, and intercultivated only when necessary to keep down weeds. The soil was a rather poor clay loam, on a gentle slope. (Pyrethrum does best in poor soils.) The plants reached maturity and produced flowers abundantly in the second season, giving yields of heads (dried, disintegrated, and pulverized) at the following rates:—

C.P.I. No.	Strain.	Yield per Acre (lb.).
2273	Swiss	1,153·2
2274	Japanese Commercial ..	1,174·4
2288	Japanese	1,256·0
2289	Japanese	1,177·3
	Average	1,190·2

Preliminary tests with the powders produced, which were carried out pending the making of provision for more comprehensive tests, showed that each was effective in destroying different insects.

The following shows the estimated cost of production per acre during the first two seasons of the above-mentioned yield (first) of flowers from the average of the four strains, based on the experience at Canberra:—

(1) Preparing flats, seeding and growing therein, and transplanting individual plants into the field (2 men—6 days at £4 12s. 0d. per week of 5 days)	£11	0	0
(2) Intercultivating and watering (1 man—3 weeks of 5 days at £4 12s. 0d. per week)	13	16	0
(3) Harvesting—cutting, drying, disintegrating and pulverizing heads (2 men—3 days at £4 12s. 0d. per week of 5 days)	5	10	0
(4) Water used, during two seasons (the period necessary at Canberra to produce mature plants, also flowers)	7	14	0
	£38	0	0
Estimated average cost per acre per annum during first two years	£19	0	0

Estimation of the average cost of production per acre per annum, with the corresponding net return per acre per annum, over a period of five years (the normal period of establishment plus productiveness), as was done from Japanese pyrethrum statistics, must necessarily await the obtaining of further results in later years.

It should be specially noted that in Europe and Japan a crop is not harvested until the third year, whereas in Australia, judging by the results obtained to date at Canberra, a satisfactory yield of flowers can be secured in the second season of growth.

5. Conclusions.

Tests conducted in Australia to date, at Canberra or elsewhere, are insufficient in scale, distribution, and duration definitely to decide the point as to whether or not pyrethrum can be grown profitably in Australia in competition with overseas production and the importation of dried flowers for processing here.

By the use of careful intensive methods—including the periodic supplying of the growing plants with adequate, though not excessive, quantities of water, it may be possible for the Commonwealth to supply her own requirements economically. It should be emphasized, however, that these requirements are small, for from figures supplied by the Commonwealth Statistician in the Overseas Trade Bulletin, No. 27, it appears that Australia imported annually during the period 1927-32 an average of 2016.4 cwt. of dried pyrethrum flowers of an average value of £12,940, the value per pound being slightly over 1s. 1d.

In other words, the planting of a few hundred acres would be sufficient to satisfy the whole of the Australian demand. The planting of any greater acreage would inevitably involve Australia entering into an export trade, and here she would have to overcome satisfactorily the effects of such factors as (i) heavy, well-organized, experienced, and economical foreign production; (ii) a rather low prevailing price for the overseas product, in consequence of a recent tendency to over-production and of depressed financial conditions; and (iii) a marked depreciation in the values of the currencies of pyrethrum-producing countries, notably Japan.

6. Literature consulted.

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5. "Relative insecticidal value of commercial grades of pyrethrum," by C. C. McDonnell, W. S. Abbott, W. M. Davidson, G. L. Keenan, and O. A. Nelson.—United States Department of Agriculture, Technical Bulletin No. 198 (July, 1930).
6. "Investigation of pyrethrum flowers from Kenya."—*Bull. Imp. Inst.*, 28: 425-427, 1930.
7. Experiments with pyrethrum in Cyprus—brief reference in *Bull. Imp. Inst.*, 28: 427-429, 1930.
8. "Select Extra-tropical Plants," by Baron Ferd. von Mueller, Government Botanist for Victoria (1895), p. 120.
9. Commonwealth Overseas Trade Bulletin No. 27 (issued annually by Commonwealth Bureau of Census and Statistics).

The Occurrence of Pilchard Eggs and Young Stages of the Pilchard in the Coastal Waters off New South Wales.

*By William J. Dakin, D.Sc., F.Z.S.**

During the past three years, certain marine biological investigations have been carried out a few miles off the coast of New South Wales, eastward of Port Jackson. This work, undertaken in conjunction with the marine laboratory of the Sydney University, has been aided by the Trustees of the Science and Industry Endowment Fund, and for that reason a rather interesting discovery, which has important commercial bearings, might be of interest to readers of this Journal.

It is, perhaps, not generally known that the eggs of most marine fishes of commercial importance (apart from the somewhat distinct groups of sharks and rays) are rather small, are produced in enormous numbers in the female fish, and are set free and fertilized externally in the sea water, where they float during their subsequent development. It is important to note this last fact. During the time that elapses before hatching, the tiny delicate eggs float about, and are carried hither and thither by sea currents with the varied assortment of minute plants and animals constituting the assemblage known as "plankton."

It is probable that the high rate of egg production in the individual fish is directly correlated with the great risks attending this mode of reproduction and the fact that a high death rate may occur during the early stages after hatching.

It is possible to determine the breeding place and date of breeding season of a marine fish by the capture of the fish eggs in plankton nets. It is also possible, in some partially enclosed waters, to form a quantitative idea of the total fish population by this means. It is essential, however, that the fish eggs can be recognized as belonging to this or that species of fish. In the North Sea, for example, as a result of years of study and exploration, all the different kinds of eggs, not only of the fishes commercially important as food, but of many other species, have been described and illustrated. Accordingly, they can be recognized under the miscroscope. This also applies to the young stages. However, we know practically nothing about the eggs of the fishes of the Australian coast, and the matter is much more complex by reason of the greater number of fish species present.

There are two methods of tackling the problem. One is to press eggs out of a captured mature female fish, fertilize them in an aquarium tank with sperm from a male fish, and then to endeavour to rear the eggs as far as possible. In this way, of course, the species of fish is obviously known from the beginning. It is not, however, a plan which can always be carried out. The other method is to catch eggs and larvae with special plankton nets, and to go on doing this until gradually, like a jig-saw puzzle, a series can be put together, leading from the egg through various sized stages from the just-hatched larva

* Professor of Zoology, University of Sydney.

until one is obtained which is big enough, or characteristic enough, to be recognizable as this or that species of fish. That, of course, supplies the clue for all the earlier stages and the egg itself. Naturally, this line of investigation requires time and patience.

During the last three years, my colleague, Mr. A. Colefax, and myself have examined hundreds of plankton catches from the New South Wales coastal waters, and each year, during the period from May to September, we have found a certain kind of egg which we thought might reasonably be regarded as belonging to some fish of the herring tribe. But no larvae later than the just-hatched stages were discovered.

This year, however, a special effort has been conducted with a large net, and every week after the eggs first appeared a search was made at sea for young stages. Over a period of six weeks, we had considerable success; each successive week bringing in a few larger individuals, until at last a stage was reached which left no doubt in our minds that the eggs were those of the Australian pilchard (*Sardinia neopilchardus*).

It is possible, therefore, to state quite definitely, not only that the pilchard is breeding off Sydney during the months from May to September, but that the numbers must be very great to give the density of eggs in the water sampled by our nets.

It is well known that the pilchard is one of the most valuable fishes to the United States of America, both for canning purposes and for oil and fish meal manufacture. The Australian pilchard is very like the European pilchard, and should can well. There should also be a demand for its oil. At the present time, however, no pilchard fishing takes place off the coast of New South Wales or Victoria. Even the gear necessary for what might be a considerable industry is lacking.

The results of this plankton investigation should supply some useful clues to the possible commercial exploitation of this fish species.

NOTES.

Tick and Blowfly Problems.—Suggested Use of the Cattle Egret Bird (*Babulcus Coromandus*).

Some six months or so ago a little attention was given throughout the press of Australia to suggestions that had been put forward that perhaps the cattle egret bird (*Babulcus Coromandus*) might be of some value, if imported into Australia, for it might serve as a means of controlling the cattle tick and perhaps the blowfly and buffalo-fly pests. Although the consensus of opinion of local authorities which the Council consulted was adverse in regard to the possibilities of the birds, nevertheless it seemed as well to obtain practical information from countries where the egret is plentiful. Accordingly, the advice of the Imperial Council of Agricultural Research, Simla, India, was sought. Recently, a helpful reply from that Council has been received. It includes the following passages:—

> " . . . I am directed to say that inquiries made of the authorities mentioned therein have not elicited any information of value other than the note on Egrets published in the Memoirs of the Department of Agriculture in India Entomological Series, Vol. III. Cattle egrets (*Babulcus Coromandus*) are quite common in the rice areas of Southern India, but not so common in the drier areas of the north. They, no doubt, consume large numbers of ticks, but, as a means of keeping this pest under control, they are quite ineffective. In certain most densely-wooded parts of Southern India, where conditions are not so favorable for the egret, cattle are liable to be infested with ticks in extremely large numbers, and it is possible that the lack of egrets may, to some extent, be responsible for this. On the other hand, in Egypt and the Sudan, where similar tick birds are very common and must consume large numbers, ticks are a very common pest. Nowhere in fact, according to our observations, have these birds, in any way, obviated the necessity for artificial methods of control, such as dipping, if ticks are ever to be brought under satisfactory control, and it seems very unlikely that the egret would have any marked effect on tick or fly infestation in Australia, particularly in the drier areas.
>
> " I am to add that no opinion can be expressed as to the likelihood of the egrets changing their feeding habits in a new environment."

Requests for Publications by Predecessors of the Council.

The response to the request in the previous issue for copies of the publications of the two predecessors of the Council, namely, the Advisory Council of Science and Industry and the Institute of Science and Industry, has already been quite helpful, and the Council is duly appreciative. However, use could be made of additional copies for which the present owners have no further use. The numbers in question are Bulletins Nos. 1 to 9 inclusive, 14, 18, 20, 21, and 26.

The F. D. McMaster Animal Health Laboratory—Field Area at "Hinchinbrook."

A brief description of the F. D. McMaster Animal Health Laboratory, and of Mr. F. D. McMaster's gift of £20,000 to cover the cost of erection and equipment of the laboratory, has been given in previous issues (Vol. 2, p. 193, and Vol. 4, p. 201). Mr. McMaster has recently added to his gift by assisting in providing the laboratory with a small area on a property he is renting at "Hinchinbrook," near Sydney.

Some time after the erection of the main laboratory, the need was felt for accommodating a larger number of animals than was possible at the laboratory itself. It also became evident that facilities for keeping sheep under natural grazing conditions would be helpful.

Accordingly, numerous properties were inspected in the County of Cumberland, and finally one which appeared suitable in every way was selected, this being "Hinchinbrook," comprising 2,000 acres, situated about 22 miles from the University, and lying to the south, on the Old Cowpasture-road, not very far from Liverpool. Difficulty, however, was experienced in leasing that portion which was suitable, and for which the necessary finance could be arranged. On learning of this difficulty, Mr. McMaster offered to inspect the property with the intention of leasing the whole of it, if he approved of it as a pastoral property, and then making available to the Council such portion as the latter required. This was subsequently arranged, Mr. McMaster taking over the leasehold of the property for three years from October, 1932. He most considerately allowed the Council to select the portion of the property most suitable for its purpose. Accordingly, an area of 300 acres was handed over and subsequently divided into small experimental paddocks. Of these there are six experimental paddocks of 15 acres each, two of 30 acres each, and two more extensive paddocks are also available for running larger groups of sheep. The section of the property selected for the Council's work is bounded by the Metropolitan Water Board's race, from which water is now siphoned to troughing in each paddock.

The necessary fencing, provision of water troughing and other material, &c., have been completed, and experimental work has been in progress for the last six months. Over 400 sheep, of which number incidentally more than 300 have been donated by pastoralists, including Mr. McMaster, Mr. E. D. Ogilvie, Mr. J. Busby, and the Camden Park Estate, are being depastured on the experimental paddocks. A two-roomed field laboratory has been erected in close proximity to the experimental paddocks, and in this erection the necessary equipment for carrying out routine pathological and parasitological examinations is installed.

Under the arrangement with Mr. McMaster, half the cost of the wages of a resident overseer are borne by him and half by the Council. The latter also meets a proportionate cost of the rent.

Experiments now in progress at "Hinchinbrook" include the following:—

(i) The determination of the effects of light, medium, and heavy parasitological infestation on young lambs, in relation to wool growth and mutton production. Indications have been obtained in other experimental work that, unless parasitic infestation reaches a fairly high degree of severity, no appreciable deleterious effects on the sheep are experienced.

(ii) In connexion with investigations on caseous lymphadenitis, 100 ewes suffering from the disease will lamb on "Hinchinbrook," and, with their progeny, will be depastured there for two years. The lambs will not enter the shearing-shed, and will be tailed, marked, and shorn at grass, so that the influence of indirect infection through contamination of shearing-sheds as against infection through other agencies will be checked and determined.

(iii) One hundred Merino ewes are being maintained at "Hinchinbrook," so that the main laboratory will have a supply of parasite-free lambs at all times. (The ewes, immediately on lambing, are brought to the laboratory, and maintained with their lambs under conditions which eliminate the possibility of the latter becoming infested with parasites.)

(iv) A small programme of cross-breeding experiments is in progress to determine the manner of inheritance of wool and mutton characters in sheep. For this purpose, 100 Merino ewes of the original Camden Park stock have been crossed with Border-Leicester rams, the latter being generously given to the laboratory by Mr. L. A. Hamilton, of Rylstone. The progeny will be classed, and a detailed analysis made of their wool and mutton characters, and the ewe progeny will be subsequently back-crossed to the Border-Leicester sires.

Bunchy-Top of Bananas.

The recent recrudescence of outbreaks of bunchy-top of bananas in various Australian banana-growing districts may serve as an occasion on which to correct the erroneous impression, extant in some quarters, that the scientific investigations on which the present system of control of bunchy-top is based were the sole responsibility of the Council for Scientific and Industrial Research and of its predecessor, the Institute of Science and Industry.

Actually, those investigations were carried out at the joint expense of the Governments of the Commonwealth, of New South Wales, and of Queensland, each party contributing on a 1:1:1 basis. The work itself was controlled by a body known as the Bunchy-top Control Board, which consisted of representatives of the contributing Governments. The main result was to demonstrate that bunchy-top is a virus disease carried by an insect vector—an aphis.

The scientific personnel available to the above Board included Professor Goddard, of the University of Queensland, as supervisor; Mr. C. J. P. Magee, B.Sc.Agr., for pathological problems; and Mr. H. Collard for horticultural work. At the time of the initiation of the investigations, Mr. Magee was an officer of the New South Wales Department of Agriculture, but his services were made available to the Board by that Department.

The report of the investigations was published under Mr. Magee's name as Bulletin 30 of the Council for Scientific and Industrial Research. Mr. Magee himself, however, has long since returned to the service of the New South Wales Department of Agriculture.

Investigations on Apple Thrips.

The occurrence of widespread thrips infestations over the southern areas of Australia has been recorded at intervals during the past 25 years; the most recent infestation occurred in the spring of 1931.

These infestations are associated with a marked reduction in the apple crop in the years concerned and with State-wide fluctuations in yields from orchards.

During 1930-31 Mr. J. W. Evans, an officer of the Division of Economic Entomology of the Council, began to investigate the thrips problem. (See this *Journal,* November, 1930, p. 239.) A large part of this work was carried out at the Waite Institute, and an account of Mr. Evans's observations was published in 1932 (Pamphlet No. 30, Council for Scientific and Industrial Research).

The Thrips Investigation League, which was formed in 1932 by growers, merchants, and others interested in the fruit industry, offered to contribute £1,200 a year for three years towards the cost of a more extensive investigation of the problem. Therefore, the research programme has been considerably extended as a co-operative enterprise between the Council, the Waite Agricultural Research Institute of the University of Adelaide, certain of the State Departments of Agriculture, and the Thrips Investigation League.

The programme consists of an investigation of *Thrips imaginis* and associated species of blossom and flower thrips, particularly with reference to their economic importance in relation to the apple-growing industry. The investigation is under the direction of Dr. J. Davidson, head of the Department of Entomology at the Waite Institute.

Certain aspects of the work are being developed at the Waite Institute, and Mr. Evans has been attached to the Entomology Department in this connexion. Mr. W. H. Wheeler has been appointed as chemist to assist with the insecticides aspect of the investigations.

Other aspects of the work are being developed in Victoria. Mr. H. G. Andrewartha has been appointed as entomologist in this connexion, and he is assisted by Miss H. V. Steele, who has been working on thrips during the past year. Through the courtesy of the University of Melbourne, this unit will be accommodated at the School of Agriculture of the University.

The Departments of Agriculture of South Australia and Victoria are co-operating in the field observations and experiments, and various growers in these States have offered certain facilities in these matters.

When suitable progress has been made in the investigation, it is hoped to extend the work to Western Australia. It is desirable to concentrate on the work in South Australia and Victoria for the present, and the results obtained will have a general application to other States.

It is proposed to publish certain results from time to time, which will serve to indicate the progress of the investigation. These results and the conclusions to be drawn from them, together with recommendations regarding control measures, will be published in the Bulletin series of the Council on the completion of the investigation.

Low Temperature Breakdown in Tasmanian Apples.

(Contributed by W. M. Carne, Division of Plant Industry.)

The object of this note is to record the common and serious recurrence of low temperature breakdown in Tasmanian apples, a disorder not previously recorded from Australia (including Tasmania).

On transferring to Tasmania in July, 1932, the writer made a survey of the wastage occurring in apples in Southern Tasmanian cool stores. By October, wastage was found to be serious and widespread, though fruit from certain orchards was much more affected than from others. Through the inspectors of the Department of Agriculture, it was ascertained that similar wastage was occurring in cool stores in the northern part of the State not visited by the writer. From the same source it was ascertained that similar wastage occurred annually, but varied in different years, 1929 being the previous bad year. The varieties affected were mainly Scarlets, Sturmer, and French Crab, the former from about August, and the two latter from about October.

On personal experience of low temperature breakdown in Bramley's Seedling, seen in England in 1931, and from published data, the principal cause of wastage in Tasmania was tentatively diagnosed as being this disorder. Low-temperature breakdown is known to develop in certain varieties in Great Britain, New Zealand, and the United States of America when stored at temperatures below 38-40 deg. F. Apples vary in susceptibility according to soil and climatic conditions, size of fruit, &c., and when very susceptible are liable to break down at even 38 deg.

As this disorder had not been previously recognized in Australia, steps were taken in 1933 to confirm the diagnosis. To this end, arrangements were made with the Department of Agriculture and the Huonville Co-operative Cool Store to provide suitable accommodation. The Department erected a small chamber in the cool store, the co-operative society providing the refrigeration. Fruit was obtained from several sources, and particularly from those orchards which had a poor reputation for the storage properties of their fruit. Certain varieties were also obtained from orchards giving fruit of good storage reputation. The following varieties were stored:—Cox's Orange Pippin, Jonathan, Cleopatra, French Crab, Sturmer, Scarlet, Delicious, and Democrat. In each instance, the fruit was divided between two chambers as under:—

Chamber.	Commercial.	Special.
Cooling system	Cold air ..	Overhead grids
Temperature at 6 feet from floor	31°–34° ..	38°–40°
Humidity	92–99 % ..	90–98 %

The storage tests will be completed about November. So far, it has been shown that low temperature is definitely associated with breakdown in Cox's Orange Pippin and Jonathan. In the former, the symptoms were typical of those recorded in this variety by the Cambridge Low

Temperature Research Station in England and by the Cawthron Institute in New Zealand. The incidence of breakdown after less than ten weeks' cool storage varied from about double to over 30 times as much at the lower as at the higher temperature, according to the tree from which the fruit was taken. The breakdown in this variety is of the soggy type, and agrees with that recorded for Grimes and Wealthy apples in Iowa, U.S.A., by Plagge and Maney (Iowa Agric. Expt. Sta., Res. Bull. 115, 1928). In Jonathan, breakdown developed in less than ten weeks' cool storage, as in Cox's Orange Pippin, but was of a mealy type. In the only line (two pickings) of this variety used, the wastage at the lower temperature was approximately twice that at the higher.

The following types of breakdown associated with storage at low temperatures have been noted to date:—

Soggy Type.—Sturmer and French Crab. Severe in 1932 in all cool stores in State. Cox's Orange Pippin in 1933.

Mealy Type.—Scarlets in 1932. Jonathan in 1933. This form in Jonathan and Scarlets has caused serious complaints on the Sydney markets in 1933. There are indications that even ordinary storage on the orchards in Tasmania is at too low a temperature for susceptible fruit.

Core Flush.—Scarlet 1932.

Standard Methods for the Chemical Analysis of Butter.

Some time ago, the Dairy Research Committee of the Empire Marketing Board appointed a sub-committee to prepare suggested uniform methods for the chemical analysis of, and reports on, dairy products. It was felt by the Committee that a useful purpose would be served if such methods were prepared by a central body and circulated to dairy research workers throughout the Empire in the hope that, if they find general acceptance, they might be adopted as standard methods. By such action, co-operative work between dairy experts in different parts of the Empire might be made of greater scientific value, since greater uniformity of results might be expected to follow the use of a common technique.

The sub-committee has recently completed the preparation of standard methods for the chemical analysis of, and reports on, butter. These have been approved by the Dairy Research Committee, and copies of them have been received from the Secretary of the Empire Marketing Board, with a request that they be circulated for the information of dairy research workers in Australia. The standard methods relate to —(*a*) sampling, (*b*) moisture, (*c*) curd and salt, (*d*) fat, (*e*) acidity, (*f*) casein, and (*g*) lactose.

Copies of the standard methods have been sent to the Commonwealth Department of Commerce, the State Departments of Agriculture, and the Departments of Agriculture at the four Universities at which Chairs of Agriculture have been established (Sydney, Melbourne, Queensland, and Western Australia). Copies of them can also be obtained by dairy research workers in Australia on application to the Secretary, Council for Scientific and Industrial Research.

The Use of Electrical Moisture Meters for Determining the Moisture Contents of Veneer and Plywood Respectively—Preliminary Investigations.

(Contributed by W. L. Greenhill, B.E., Division of Forest Products.)

The Division of Forest Products has done much to popularize the use of the Blinker electrical moisture meter for determining the moisture content of timber. This instrument and its use are described fully in the Division's Trade Circular No. 9. It depends for its operation on the variation of the electrical resistance of timber with moisture content. The type of electrodes usually employed consists of two steel blades attached to the head of a special hammer, the blades being driven into the piece of timber which is to be tested. The use of these blades becomes impracticable when the specimen to be tested is less than about ¼ inch in thickness, as the timber splits and satisfactory contacts between the timber and the blades cannot be obtained. Besides this, the marks made by the blades would be very undesirable in thin veneer material.

With the object of investigating the possibility of extending the use of electrical moisture meters to include the testing of veneer stock, preliminary investigations were carried out on the use of plate electrodes with the veneer clamped between, and on the measurement of the electrical resistance across the timber in that way. This method can be successful only when testing very thin stock in which appreciable moisture gradients are absent. Measurements were made to investigate the effect on the electrical resistance of variations of the pressure between electrodes, area of electrodes, thickness of timber, and species of timber tested.

The results indicate that:—

(i) Provided the pressure between the electrodes is above a certain minimum, the resistance is practically independent of the pressure. The value of this minimum resistance varies from sample to sample, and apparently is that necessary to flatten out the veneer and secure proper contact.

(ii) As would normally be expected, the resistance is proportional to the thickness of the veneer and inversely proportional to the area of the electrodes.

(iii) The resistance varies with the species of timber.

(iv) With veneer sheets of the usual range of thicknesses, the resistance between suitably proportioned plate electrodes is less than that between the blades of the ordinary Blinker hammer, the species and moisture content being the same in the two cases. It should be possible to extend the lower limit of the ordinary Blinker range of readings of moisture contents by 1 or 2 per cent.

(v) The electrodes must be placed a reasonable distance in from the edge of the veneer sheet being tested, and checks in the sheet are likely to render the readings inaccurate.

There appear to be no theoretical difficulties in the way of using the surface type of electrodes and calibrating an ordinary Blinker to give the moisture content of veneer sheets of any one thickness and species, from about 6 per cent. to about 20 per cent. The change of resistance

with moisture content is so rapid at the lower end of this range, that if an instrument were calibrated on, say, 0.05 inches thick veneer, the effect of variations in the thickness of the veneer from 0.025 inches to 0.075 inches would be completely overshadowed. Thus, variations in thickness of veneers of this order would give rise to errors of not more than 0.5 per cent. in the moisture content determination, if the moisture content itself were 9 per cent. or less.

A design of suitable equipment for carrying the electrodes for testing veneer sheets of commercial size has been developed. In this, the arms carrying the two electrodes extend out for 18 inches to 2 feet, so that tests can be made near the centre of ordinary sized veneer sheets. After the sheet is inserted between the electrodes, these are forced together by means of a spring, and the moisture content reading is made. A small hand lever is used for removing the pressure of the spring.

Tests have also been carried out to investigate the possibility of determining the moisture content of plywood, as distinct from plywood stock, by means of a Blinker, but the results are not promising. Casein glue is most commonly used in plywood construction, and, apparently owing to the varying constituents and amount of glue used, reliable moisture content indications cannot be obtained by electrical resistance methods. The resistance of the glued wood is considerably less than that of the wood alone, and the results obtained may give the moisture content from 2 to at least 7 per cent. above the actual value. No tests have been made with animal or vegetable glue, but it is probable that glues of either of these types would not affect the electrical resistance of the wood to the same extent as casein glue.

"Industrial Research and the Nation's Balance-sheet"—Excerpts from an Address by Sir Frank E. Smith, K.C.B., D.Sc., Sec.R.S., &c.

A few printed copies of the 8th Annual Norman Lockyer Lecture, which the Secretary of the British Department of Scientific and Industrial Research, Sir Frank E. Smith, delivered to The British Science Guild in November last, have recently become available in Australia. In emphasizing the importance of research, the speaker mentioned a number of interesting points. Some of these are quite familiar, but many others have not been the subject of much public attention in this country. A few extracts are given below:—

> "The nation's most valuable plant is in the form of buildings. It is difficult to give a precise figure for the value of buildings in this country, but as the rateable value was about 250 million pounds in 1931, a reasonable estimate of value is 4,500 million pounds. There is no doubt that science can help more in planning our buildings, and it can show the builder how to choose his materials and to build better than he does at present. The costs for wear and tear per annum cannot be less than 50 million pounds, and the obsolescence charges are enormous. Research can help reduce them and make our greatest material asset much more valuable and less costly to maintain."

"It is true that years ago we were prosperous without organized industrial research, but it is equally true that to-day we shall fail without it."

"Research has not only improved old products and replaced old types by new and more efficient ones, it has also produced new industries. The industries associated with artificial silk, synthetic nitrates, the motor car, wireless, the cinema, and the aeroplane were unknown 50 years ago. To-day they employ many millions of workers."

"The electrical industry is older than that of the motor car. Its progress has been very rapid, and it is certain that its advance will continue. Yet we cannot see the entity which we pay for to light our homes and use for many other purposes. Why is it that progress has been so rapid and the future is so assured? I believe it to be due to the absolute necessity for those who control the technical side of the electrical industry to be men of the highest intelligence. They know that their industry was born of science, lives with science, and without science would perish. Although the entity with which they deal cannot be seen, I believe more knowledge is available of the nature of this invisible entity than is available of the nature of many of the material things seen, handled, and sold in other industries. For example, coal. If only a big research effort to determine the nature of coal had been made 50 years ago the industry would not have been in the troublous straits it is in to-day."

"Most people admit that it is good for the motor car to become better and its tires to be cheaper and have a longer life. It is also well for electrical supplies to become more general, more efficient, and less costly. It is even good for simple things like our pocket knives to be improved by research and become better and cheaper. But there are still many who believe that in the mundane things of life such as coal, cast iron, bricks, and blankets, finality has been reached, or nearly so. However, a survey of what has been done and of the knowledge available and not used makes it practically certain that there is no product of any kind which cannot be improved in quality and produced more cheaply by properly conducted research. There is no limit to knowledge, and there is no limit to technical progress. If a country had to choose between new knowledge and gold with which to fill its vaults, the wise choice would undoubtedly be new knowledge, for with it the gold can be obtained, whereas without it the gold will be lost. I believe it to be essential for our industries to avail themselves of existing knowledge and to conduct research on an adequate scale to acquire new knowledge."

"It is impossible to enumerate here the many developments due to these laboratories. They comprise apparently small things, such as a grease having negligible vapour pressure in a vacuum, to bigger things like synthetic manures, non-creasing cotton fabrics, manganese steel, and silicon steel. The latter alloy alone is estimated to have saved the world over £50,000,000 by reducing the energy losses in electrical transformers."

"Consider, for example, the photo-electric cell, which twenty years ago was a mere toy of the laboratory. To-day it is a vital link in the talking pictures; it is used as a burglar alarm; it operates in large stores to switch lights on or off with variation in daylight illumination; it groups electric lamps according to their candle-power; it arranges cigarettes in rows with the imprinted name uppermost; it selects cigars by the colour of the outside leaf; it controls the magnitude of electric currents, and it is used in television. What a change in the toy of twenty years ago!"

"It is a striking fact that to produce the same useful power seven times as much steam was required in 1888 as in 1930, and over 30 per cent. more in 1918 than in 1930. Finality has not yet been reached. At the time of his death Sir Charles Parsons was engaged in still further improving the efficiency of the steam turbine."

"In this short address I have attempted to press the claims of research not only in our industries, but also in the technical affairs of the nation. Science is but attempting to use the materials of the earth to the best advantage; Emerson's statement that 'Steam is no stronger now than it was a hundred years ago, but it is put to better use' is but an expression of what science is doing, putting to better use all the materials of the world around us. Progress in science is progress in civilization, but progress in control of production, in freedom of currencies, and like matters, is also essential if the world is to reap the optimum benefit."

Recent Publications of the Council.

Since the last issue of this Journal the following Bulletins and Pamphlets of the Council have been published:—

Bulletin No. 75.—*Nigrospora Musae* n. sp. and its Connection with "Squirter" Disease in Bananas," by Associate-Professor Ethel I. McLennan, D.Sc., Botany Department, University of Melbourne, and Shirley Hoëtte, M.Sc., Botany Department, University of Melbourne.

The investigations discussed in this Bulletin were carried out by the Botany Department of the University of Melbourne quite independently of the Council, and the latter is indebted to the Department and to the investigators concerned for the work done and for their kind acquiescence in the suggestion that their results might be published as one of the Council's Bulletins. The results of the work go to show that "squirter" in bananas is due to a fungus. The writers have isolated the fungus, and identified it as a new species of *Nigrospora,* to which they have given the name *N. Musae.* The seasonal nature of the disease has been associated with the temperature range of the fungus. It is during the winter and early spring that plantation and transport temperatures are favorable to the growth of the causal organism and render infection in the field and subsequent growth of the pathogen during rail transport both possible and probable. The localization of "squirter" to fruit ripened in the southern markets has

been correlated with the method of packing fruit in "singles," a method until recently not adopted in Brisbane, where "squirter" was formerly practically unknown. Work on further aspects of the problem is in progress.

Pamphlet No. 38.—"The Occurrence of *Anaplasma marginale* Theiler, 1910, in Northern Queensland," by J. Legg, D.V.Sc.

The work discussed in this Pamphlet forms a part of a programme of investigation which is being carried out at Townsville, Queensland, with the co-operation of the Empire Marketing Board, the Queensland Department of Agriculture and Stock, cattle-owners of Queensland, and the Queensland Council of Agriculture. It represents a preliminary survey of the piroplasmic diseases affecting bovines in Australia. The report shows that, in addition to the well-known *Piroplasma bigeminum,* at least three other types of parasites affecting the red blood corpuscles of bovines, and resulting in "redwater," occur in Australia, namely, *Theileria mutans, Anaplasma marginale,* and a form of *Babesiella.* A considerable amount of attention is given to *Anaplasma marginale,* which leads to serious forms of the redwater disease. The previously unsuspected existence of *A. marginale* is no doubt the explanation of the rather numerous unsatisfactory results that have followed practical operations of immunization against redwater in the past.

Pamphlet No. 39.—"The Grasslands of Australia and Some of Their Problems. A Report upon the Dairy Pastures," by William Davies, M.Sc., Empire Grassland Investigator, Welsh Plant Breeding Station, University College of Wales, Aberystwyth." This publication consists of a report which Mr. Davies made to the Australian Dairy Council subsequent to the twelve months or so which he recently spent in Australia, the visit itself being financed by the Empire Marketing Board and the Australian Dairy Council. The different varieties of Australian pasture grasses of importance are discussed at some length, and, in all cases, stress is laid on the importance of strain. A discussion of soil fertility in relation to pasture management is included, and it is pointed out that the objective of manuring is to maintain uniform botanical composition of a good pasture once established and not to promote violent floristic changes, which is too often the case in practice. Several important points regarding the management of grasslands are mentioned, and due emphasis laid on the conservation of fodder and the use of the mower as a grassland implement. Suggested ways in which research and demonstration plots in the various States of the Commonwealth might be laid down and organized are given.

Pamphlet No. 40.—"A Guide to the Seasoning of Australian Timbers—Part 1," by C. Sibley Elliott, B.Sc., Division of Forest Products.

As a result of the constantly increasing interest being given in Australia to kiln-seasoning, the Division of Forest Products receives so many requests for drying-schedules for specific Australian timbers that it has been decided to publish, in a collected form, such information in this regard as is available. That action has been taken in the Council's Pamphlet No. 40. The publication discusses the seasoning of seventeen timbers, including two exotic timbers grown in Australia, namely, insignis or Monterey pine and willow.

Pamphlet No. 41.—"The Grading of Western Australian Timbers. Report on, and suggested Specifications for, the Grading of Jarrah and Karri, based on Investigations in 1932," by F. Gregson, B.E., and R. F. Turnbull, B.E.

This publication covers a co-operative field study extending over the latter half of 1932 on the grading of jarrah and karri with a view to the preparation of suitable grading rules to cover the supply of major products in these timbers. Recommended grading rules and specifications are given for all sizes of jarrah ordinary building and construction timber, jarrah flooring, jarrah and karri mine skip guides, karri cross-arms and jarrah paving blocks. Field studies on the relation of cutting sizes to nominal sizes and variation in sawing are also dealt with, and tentative recommendations are made showing what are considered to be reasonable allowable variations in sawing.

Pamphlet No. 42.—"Meteorological Data for Various Localities in Australia" (in co-operation with the Commonwealth Meteorological Bureau).

For some time past, scientific investigators throughout Australia have made extensive use of the meteorological data collected by the Commonwealth Meteorological Bureau of the Commonwealth Department of the Interior. Such data have been of value in a number of directions, and especially in connexion with researches concerning many different subjects in the fields of soils, entomology, plant industry, animal health, &c. In co-operation with the Bureau, this Pamphlet has accordingly been issued. It gives details of the normal mean maximum temperatures, the normal mean minimum temperatures, the normal mean relative humidities, and the average rainfalls in points for some 380 odd selected meteorological stations throughout the Commonwealth. The subject-matter of the publication has been arranged in meteorological divisions, and the stations for which data are given have been selected from the point of view of their being as representative as possible.

Forthcoming Publications of the Council.

At the present time, the following future publications of the Council are in the press:—

Bulletin No. 74.—"Observations on Soil Moisture and Water Tables in an Irrigated Soil at Griffith, New South Wales," by E. S. West, B.Sc. (Adel.), M.S. (Calif.).

Bulletin No. .—"A Soil Survey of the Hundreds of Laffer and Willalooka, South Australia. Report of the Division of Soils." Edited by J. K. Taylor, B.A., M.Sc.

Pamphlet No. 43.—"Investigations on the Buffalo Fly, *Lyperosia exigua* de Meij.," by G. L. Windred, B.Sc. Agr. (and in part by Dr. B. J. Krijgsman).

H. J. Green,
Govt. Printer, Melbourne.